PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *EDITOR*

McGRAW-HILL PUBLISHING CO., INC. NOVEMBER 1938 VOLUME NINE, NUMBER ELEVEN

What Makes a MASTERPIECE?

IN HIS BOOK, "The Winning of Barbara Worth," Harold Bell Wright described a great engineering achievement, the transformation of desolate desert wastes into a great fertile valley covered with fields of billowing grain and groves of flowering fruit trees and dotted with cities and hamlets. It is a story packed full of engineering romance and the glories of its accomplishment in creating a masterpiece.

In this story, Harold Bell Wright did not detail the mixture of concrete used, how the forms were built, how the concrete was poured. Nor did he explain how the difficult engineering problems were solved, what formulas were applied, or how an exceptionally intricate engineering difficulty was surmounted. Perhaps Mr. Wright did not possess the engineering knowledge to write about such details. But had such details been included the story would have been spoiled. An achievement is a masterpiece not by virtue of the difficulties encountered in its creation but by virtue of the emotions and inspirations that the accomplishment arouses.

The Cathedrals of Europe, the Last Supper by Leonardo da Vinci, a nation's national anthem, the pyramids of Egypt, the architecture and statuary of Greece—all are masterpieces for what they are and not by reason of the difficulties under which they were created. The same may be said of the steam turbine, the telephone, radio, the machinery of production and construction and the thousands of other creations of engineers.

It is only human that one have a tendency to judge the greatness of his accomplishment by the effort required and the ingenuity exercised. A "tricky" design is always intriguing, especially to the one who developed it. Only too often the engineer permits such thoughts to overshadow the reality of his accomplishment or the lack of it.

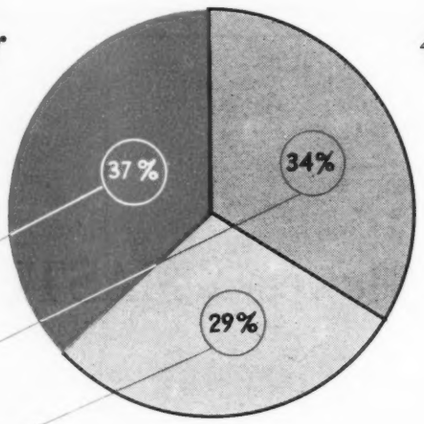
Conversely, there is always a tendency to allow the drabness of engineering calculations to blot out its romance and drama. The details of the procedure may obscure the objective. Of course every detail of a design must be calculated accurately and considered carefully. The right materials must be used, every part must be correct in size and shape and everything must go together properly. But these are only the tasks, chores perhaps, that are the means to an end—the creation of a masterpiece.

And what is a masterpiece in engineering design? The answer cannot be given in words. If when gazing at the finished product it provokes the same feelings as experienced in the first view of a grand cathedral or an object of fine art—or if it brings forth visions of a great service to humanity, making people happy, giving them greater opportunities, serving their needs or relieving suffering—it is a masterpiece. But if it does not possess any of these attributes, it is just another design, another job out of the way to make room for another one to be tackled.

Only those who can visualize and feel the romance and drama in engineering design can create its masterpieces, for every masterpiece embodies the spirit of its creator.

Engineering Design ACTIVITIES

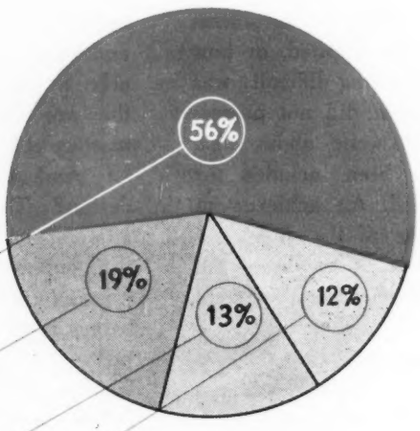
As reported by *460 manufacturers*



Are or have been increasing their engineering staff during the past year

Neither increased nor decreased their engineering staff during the past year

Have not increased the staff above the low point during the past year

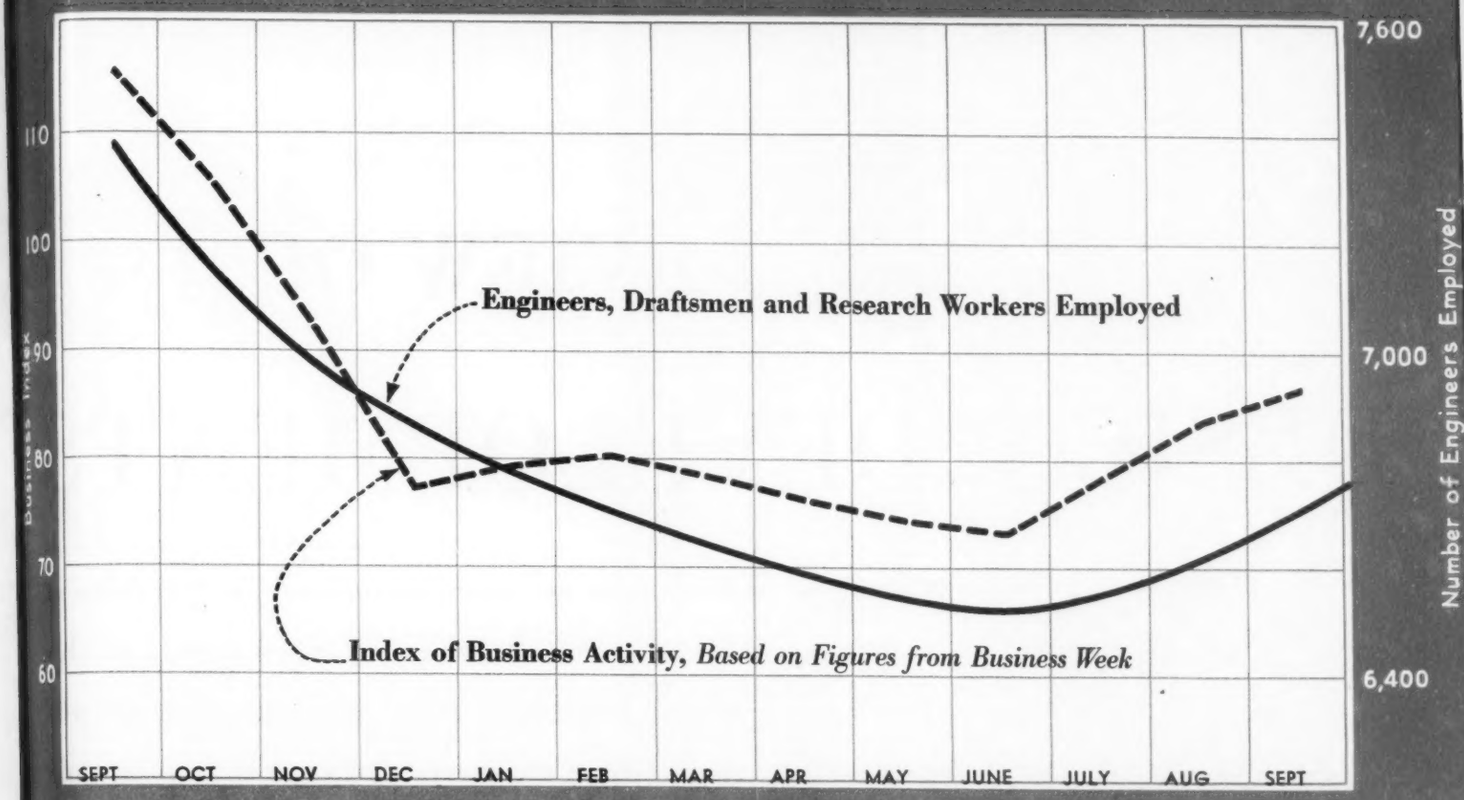


Expect to increase design activities during the coming year

Have as many or more engineers than year ago but plan no further increase

"Don't know" — "Doubtful" — "Maybe" — "Not materially"

Have smaller engineering departments and do not plan to increase soon



Engineering Employment REPORTED BY 460 COMPANIES

COMMENTS

We are now developing a line of flexible shaft driven machines and have almost doubled our engineering department since January to produce these designs.—Small Tools Manufacturer.

Expect to develop a full line of gas burners for all sorts of applications. This line is new to our business.—Heating and Ventilating Equipment Manufacturer.

We are considering developing several entirely new products. Work has just been started on a few. In addition to this all of our equipment is designed special to meet the customer's specifications with reference to such things as types of drives and controls.—Shop Equipment Manufacturer.

We did not lay off any designing engineers during the past year but transferred some to the sales and service department in order to give them the opportunity of getting first hand information on requirements as to design. All of these men are now back in the engineering department and although we do not expect to increase our staff during the coming year there will be no drop.—Aeronautical Engine Manufacturer.

Our whole line is being redesigned and we have added 23 engineers to our staff during the past year.—Automotive Equipment Manufacturer.

We are now designing new molding machines in addition to numerous special designs of such machines.—Press Manufacturer.

We did not have any low point in our engineering staff during the past year but have been steadily increasing the department.—Aircraft Manufacturer.

(This is typical of the reports received from fourteen aircraft manufacturers and manufacturers of aircraft equipment. Figures indicate an increase of about 100 per cent in activity in this field over the past year.

We expect to increase our design activity during the coming year, in conformity with our policy that in times of business depression design activity should be at its peak.—Press Manufacturer.

During the past year we increased our engineering department from 18 to 24 men and we expect to increase somewhat further during the coming year. This has been necessitated by the fact that we are designing special tractor units for road graders and industrial uses.—Farm Equipment Manufacturer.

About 60 per cent of our engineers are working on special designs and we expect our engineering activity during the coming year to be about the same as this year.—Machine Tool Manufacturer.

We are now developing a large number of new items including combination units, in addition to which we are redesigning about 30 per cent of our present line.—Heating and Ventilating Equipment Manufacturer.

Our engineering department has worked steadily throughout the past year with the same number of men, developing designs for four different types of new machines. Our machines are in a state of constant development in order to meet the demands of changes in textile styles and materials.—Textile Machinery Manufacturer.

A REVIEW OF DESIGN DEVELOPMENTS

Continued improvements and new developments in the fields of materials, mechanical parts, electrical devices and surface finishes have opened up new possibilities and opportunities, and descriptions of this field of activity are always a help and an inspiration to engineers in designing better, more desirable products. This survey, presented in brief paragraph form, is illustrated by photographs and detailed views showing particular applications of new developments in recently-announced product designs

Under the stimulus of industrial research, with the constant, competitive effort to improve performance, economy and appearance in all types of equipment, new developments are being made continuously in materials, parts and processes. Any attempt to separate the new from the old is inevitably futile; new developments mentioned are new in the sense that they are now commercially practical, not necessarily new in the sense of discovery. The aim has been to set forth as briefly and clearly as possible those practical improvements in materials and parts that will interest and aid the designing engineer.

It is difficult and often impossible to credit a given development to any one company. Usually a number of companies have made similar developments, but the space available does not permit covering all of them. Names, therefore, have been purposely omitted, although all of the information in this review of developments has been obtained from and checked with recognized companies.

Key numbers have been placed at the end of each paragraph or paragraphs wherein a new development is described or discussed. Any reader desiring further information will be furnished on request the name of the company which supplied the information with other details, if the number of the item of interest is specified. It must be understood, however, that in furnishing data on companies, names can be given of only those companies that are known to have available the products to which the item refers. It is entirely possible and, in many instances, most likely, that other companies have similar developments.

METALS AND ALLOYS

ALLOY CAST STEELS. In cooperation with the designers of industry, who are constantly asking for materials that will stand up under harder service conditions than those existing in the past, metallurgists engaged in foundry practice have been working with a variety of cast steel alloys to meet the changing service requirements. Alloy cast steels have been developed that possess improved physical properties to satisfy the requirements of higher temperatures, greater pressures, greater strength, acid-resistance, wear-resistance, and greater machinability.

The list of industries that are using cast alloy steels is rapidly growing. Alloy cast steels are now being used by: builders of machine tools, high speed transportation units, steam turbines, valves and fittings. Manufacturers of railway, automotive, excavating, chemical processes, pulp and paper, petroleum refining, rayon manufacture, marine and aeronautical equipment are finding new uses for alloy cast steel. The variety of properties required by this long list of industries has given rise to the development and manufacture of a large number of specific alloys to satisfy individual requirements.

Many designers whose products are subjected to repeated shocks such as pneumatic tool parts, light-weight streamline railway car parts and special turbine castings are specifying and using a medium manganese steel with a 0.25 to 0.40 carbon range. Castings made of this analysis are given a complete heat-treatment to develop high physical characteristics.

For special power machinery parts, such as crankshafts, it is important to have a steel of good machining qualities in addition to high physicals. For this service a manganese-chromium-molybdenum alloy with a carbon range of 0.25 to 0.40 is giving good service because of its high tensile and yield values with maximum ductility. A steel noted for its wearing qualities and good toughness is a manganese-chromium-molybdenum alloy with a 0.40 to 0.55 carbon range. It is used to a great extent for gears, special rolls, cams and also for excavating and drilling equipment.

Carbon-molybdenum steel having a carbon content of 0.20 to 0.30 with molybdenum 0.40 to 0.60 has been found to give good service in parts that are subjected to steam temperatures up to 850 deg. F., in valves, fittings, and turbines.

Parts which are exposed to sub-zero conditions, such as return headers, valves and pump castings used in dewaxing processes are being made from 2.25 to 3.25 per cent nickel steel to obtain good impact values at the lower temperatures.

An alloy which is resistant to the cor-

rosion action of alkaline solutions and most organic chemicals which is used by some builders of equipment for producing nitrogen and nitrate acids, contains 18 to 20 per cent chromium with approximately 0.30 carbon. This material is used for valve bodies, disks and seats. Stainless alloys are in demand for chemical equipment, textiles, cannery, dairy and food machinery. In these fields the requirements are most exacting, for this service an 18 per cent chromium, 8 per cent nickel, 0.07 per cent carbon alloy, stabilized with molybdenum, columbium, or selenium where service conditions dictate, has found general acceptance. This alloy is recommended where welding is imperative.

A popular grade of stainless alloy used in the processing industries, for valves, fittings, pumps and equipment, where a corrosion resistant material is necessary, is an 18 per cent chromium, 8 per cent nickel, 0.20 per cent carbon.

In the sulphite industry a metal is needed that is highly resistant to the action of sulphur compounds at elevated temperatures for pumps, digester fittings, valves and general equipment. The same properties are needed for parts exposed to high temperatures in the presence of fuel with high sulphur content. To meet these severe conditions a 24 per cent chromium, 11 per cent nickel, 0.20 per cent carbon max. alloy has been developed. For greater resistance to sulphurous acids, dilute sulphuric with sulphurous acids, and sulphuric with nitric acids, a 28 per cent chromium, 11 per cent nickel, 0.30 per cent carbon max. alloy is available. (1)

STAINLESS STEELS that are suited to a great variety of services and designs have resulted from modifications in the composition or analysis. In addition to chromium, elements such as nickel, molybdenum, silicon, manganese, copper, tungsten, titanium, columbium, selenium, and others have been added to produce modified stainless steels with a resultant broader range of available properties.

The most recent of these modifications are concerned with manganese, molybdenum and columbium. Contemporary research has shown the value of increasing the limits of manganese in chromium-nickel steel. The higher manganese steels seem more ductile at high temperatures, to have improved welding qualities, and to be less susceptible to tearing while being fabricated.

Columbium is sometimes added to the chromium-nickel steels to stabilize carbides so that the steels will retain their full corrosion resistance at all operating temperatures even after being held at temperature ranges which might cause deterioration in unstabilized steels. The columbium-bearing steels can be used in corrosive media without annealing after welding.

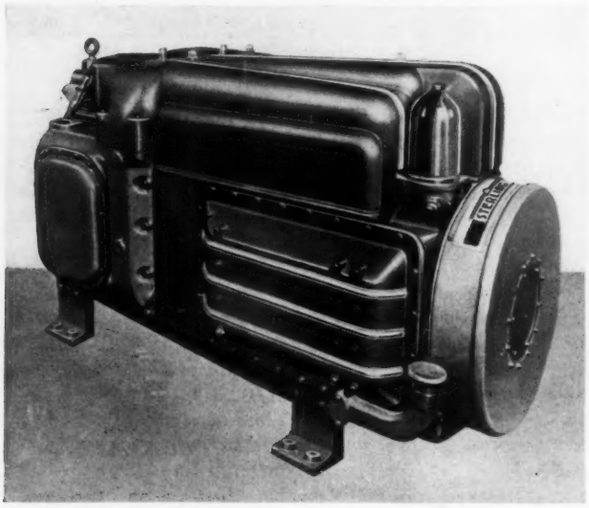
Molybdenum (2 to 4 per cent) increases the corrosion resistance of 18–8 steel to neutral and acid media. Greater resistance to pitting and contact corrosion is gained by addition of both molybdenum and columbium.

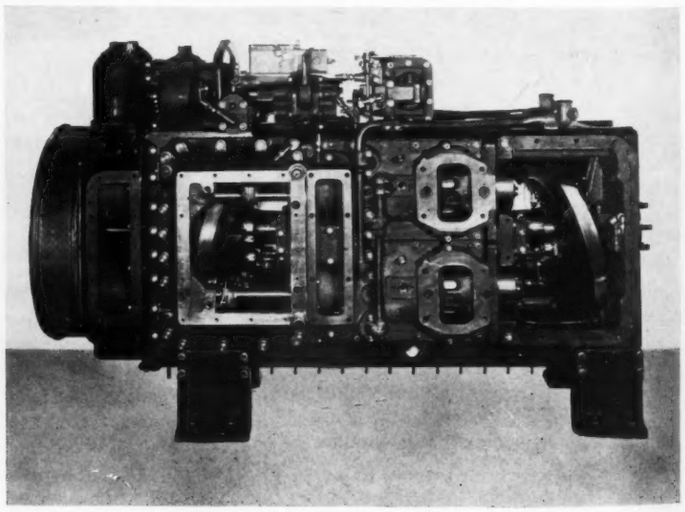
ORDINARY STEEL can now be made hard enough to cut glass and yet remain so ductile that it can be bent double. Now in commercial use, a method of getting alloy steel properties in certain grades of carbon steel, heretofore found only in the more costly alloy steels, may bring to the general public great savings in small tools and springs, and a wide range of small steel products where hardness is required. Carbon steel hardened and tempered by the usual methods, snaps when it is bent, but the same steel heat-treated to the same hardness by the new process, called austempering, can be bent to almost any desired angle. This property is particularly desirable where great hardness and toughness are desired, as in garden tools, shovels, chisels, dies, and springs.

The essence of the process is the quenching of the steel into a bath of molten lead, salt, or any substance capable of withdrawing heat quickly from the steel, without combining chemically with the product, and holding it there for a predetermined period. While held in this molten bath the steel undergoes a transformation in a period of time depending upon the temperature of the bath and the composition of the steel.

In general, the lower the bath temperature the higher the strength and hardness and the lower the ductility of the treated steel. Likewise the lower the bath temperature the longer the time necessary to complete the transformation, although there may be certain exceptions to this rule.

Crankless Diesel Engine . . . . . .





Sterling Diesel Engine, which operates as an opposed-piston wabble-plate engine, incorporates many new refinements in alloy materials and assembly. The shaft is 4645 chromium-nickel-molybdenum heat-treated steel, the inclined disks are 4615 alloy steel die formed, hardened, ground and lapped, and the gears for accessory drives are steel forgings of 1020 steel, hardened and ground. Cylinders, of alloy cast iron, are mounted horizontally and are removable individually. Slipper bearings are of die-forged, hardened steel, and have babbit-faced bearing surfaces; the slipper sockets are steel, bronze lined. There are no valves, since the pistons passing air intake and exhaust ports are timed as valves.

In austempering the steel is quenched in such a manner that the formation of hard, brittle martensite is avoided. Once in the molten bath it undergoes a slower transformation, which, when complete, yields a crystalline structure which differs from martensite, the characteristic constituent of fully hardened steel. This newly discovered structure exhibits an unusual combination of high hardness and ductility coupled with improved impact strength. At present, austempering of plain carbon steels is limited to sections which can be cooled with sufficient rapidity to prevent transformation during the quench to the austempering bath temperature. If too thick, heat cannot be withdrawn from the steel rapidly enough in cooling it to the austempering bath temperature. Experience indicates that the upper limit of thickness probably lies somewhere between ¼ and ⅜ in. for carbon steel which can be successfully austempered. (3)

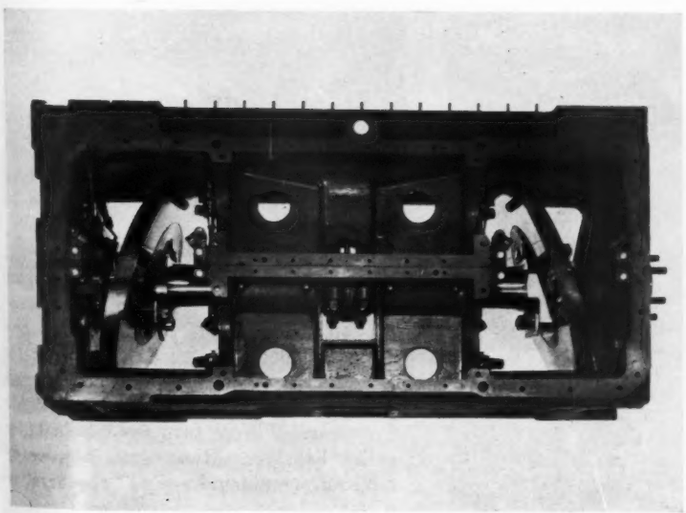
CREEP DEFORMATION during the last year and a half has been given much special study by metallurgists. As a result of their studies, they have concluded that reliable data cannot be obtained unless the specimens are subjected to creep tests for a period of at least 3,000 hr. using electric furnaces of special design and capable of maintaining a temperature within plus or minus 1 deg. F. throughout the specimen. (4)

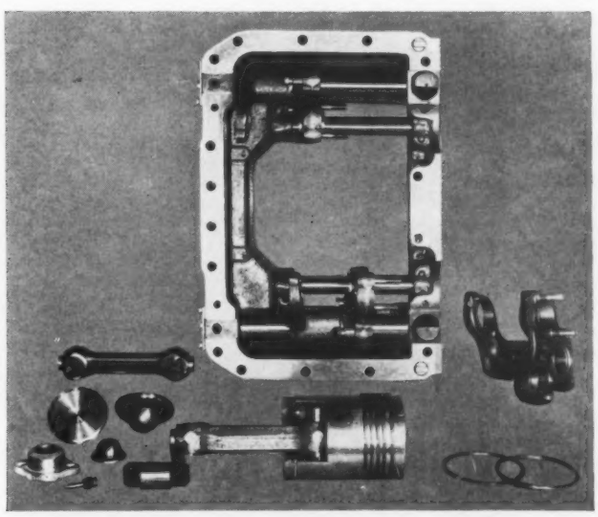
HIGH TENSILE MANGANESE STEEL is used to reduce weight in drum shell of a concrete mixer shown above. This material is light in weight, yet it withstands heavy stresses and abrasive action. Mixing blades in the unit are made of the same material. The drum-drive gear is welded to the drum head on the engine end. This gear is made of high carbon rolled steel, it is the only gear on the drum, and is driven by a forged steel pinion attached to the gear reduction shaft. (5)

COLUMBIUM ADDED in small quantities to stainless steel has a stabilizing influence on alloys used in heat exchangers, autoclaves, and similar apparatus in the chemical industries. The addition of

To withstand abrasive action and shock loads, high tensile manganese-alloy steel is used for the drum shell and mixing blades in the Ransome truck mixer. Blades are especially designed to give a uniform mixing action without clogging. Reversal of drum rotation causes a screw action of the blades, forcing the mixed concrete out regardless of truck position relative to horizontal. Drum rotates on a self-aligning bearing at one end and two drum rollers, mounted in tapered roller bearings, at the other end. End rollers are made of electric steel, case-hardened

. . . . . *Redesigned for Simplified Assembly*





Two housings, which divide on the shaft center, comprise the main frame assembly. The framework which carries the piston guide rods is a sub-assembly which bolts to the main frame. Power generated by combustion is directly applied to the inclined disks rigidly mounted on the ends of the center shaft. The mechanical bearing units which transfer the power from the pistons to the rotating disks involve the same principle employed in Mitchell and Kingsbury thrust bearings used in marine work. The bearings, universally mounted, are free to adapt themselves to the plate angle. The crankless construction permits the adoption of the opposed piston principle, without complicated parts.

columbium to stainless steel imparts a stability of structure which keeps the strength and corrosion resistance of stainless steel at a high value even after operating for months at high temperatures. Columbium-bearing stainless steel has also been used for linings in equipment that is subjected to high pressures and high temperatures. The lining is welded to a backing of plain carbon steel. (6)

ALLOY STEELS. Strength, toughness and resistance to shock and abrasion are the recognized advantages of alloy steels, but these are obtained only after the steel has been subjected to accurate heat-treatment. A scientifically controlled heat-treatment involves the use of rather elaborate equipment and the employment of expert, trained personnel, which is only economical when carried out on a relatively large scale. Many applications exist where heat-treated alloy steel could be used, but where the quantity involved is not sufficient to warrant setting up heat-treating equipment and personnel. To remedy this condition alloy steels that are heat-treated to definite physical properties to suit many different purposes are now carried in stock to fill small orders. (7)

BRUNORIZING for railroad rails, it has been reported, practically eliminates the wearing down of the rail ends, known as "batter," caused by the hammering action of the wheels leaving the rail ends. This is essentially a process wherein the steel rail is initially allowed to cool only to a few hundred degrees below its critical temperature, is then reheated to above its critical temperature and then allowed to cool completely. The process refines the grain structure of the metal as a result of which the life of the rail is materially increased. (8)

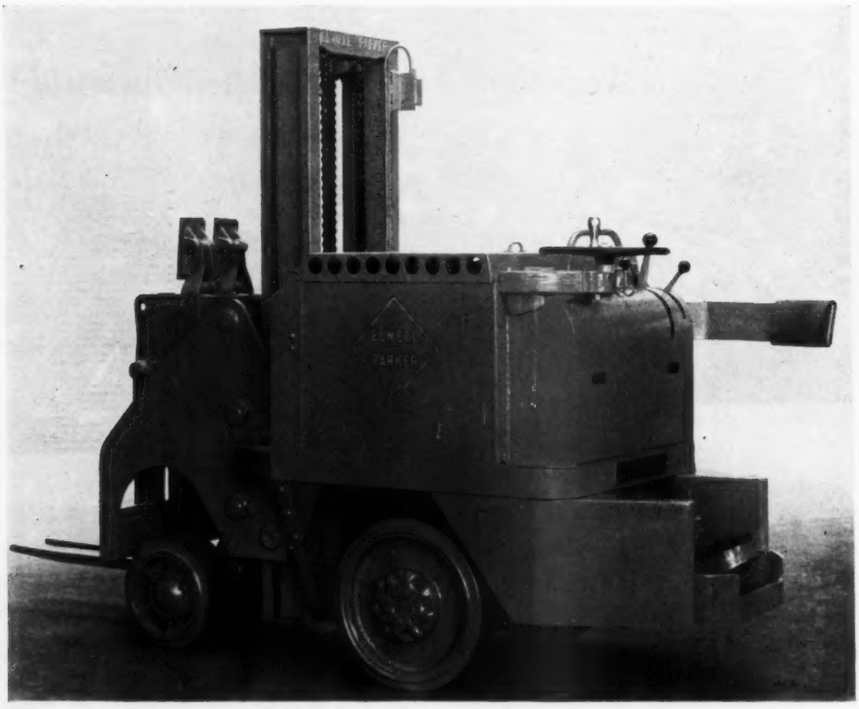
HIGH STRENGTH LOW ALLOY STEELS have during the past two years come into more general use specifically for freight cars, railway cars, streamlined trains, gasoline tank wagons, mine cars and many types of portable machinery. These low alloy steels have about one and a half times the strength of ordinary steels. Some of these steels have exceptional corrosion resisting properties which make them especially suitable for applications where light weight is a prime consideration. By virtue of their corrosion resistance they permit the use of thinner sections as no allowances need be made for loss of thickness through rusting. (9)

LESS DEAD WEIGHT and greater pay loads have been the guiding motives in the design of a dump car with a bed of all-welded design. Alloy steel was also used to obtain a maximum strength as well as light weight. The dump cylinders of this car are also made of plate and are welded. The non-pressure heads of the cylinders, as well as the piston heads are also made of plate and welded construction. A reduction in weight of 12,000 lb. has been attained as compared with the previous design. (10)

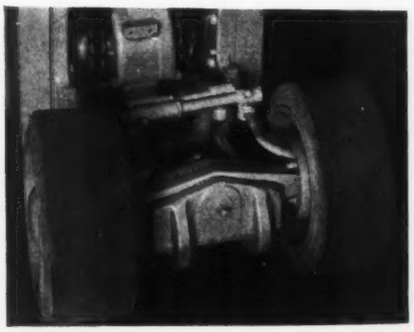
ALLOY STEEL WELDING ROD for gas welding is now available which has been designed to meet the present day demand for increased ductility and improved quality of both single and multi-layer steel welds. It is able to withstand considerable heating without burning. Some of the physical characteristics of the new rod are: free bend ductilities of single layer welds range from 20 to 30 per cent depending upon the composition of the steel; free bend ductilities of multi-layer welds up to 40 per cent on low or medium carbon steels; ultimate tensile strengths in excess of 60,000 lb. per sq. in.; specific gravity of welds 7.80—7.86; charpy impact values on keyhole notched specimens at 70 deg. F., from 15 to 30 ft. lb.; Rockwell hardness of weld metal from B60 to B85 depending on carbon content of the base metal and also on the type of weld. (11)

CAST IRON is constantly being greatly improved by virtue of the use of alloying elements such as nickle, chromium and molybdenum and also as the result of

Alloy Steel Forgings



Elwell Parker F-10 industrial truck, designed to handle tin plate, obtains toughness and strength in highly-stressed members by the use of alloy steel forgings. Truck is available with battery or gas-electric unit, as desired.



Trail axle is one-piece forged bar pivoted at the center to permit compensating motion on rough runways. Large section drop forged steering arms and knuckles placed above axle give greater runway clearance and increased accessibility. Steel ball joints are adjustable for wear. Wheels turn in double taper roller bearings. Hoist unit is powered with a compound-wound regenerative motor. An overload clutch and ratchet protect hoisting mechanism. Solenoid brake on hoist motor locks load in position. Forks are automatically stopped at limits of travel through contact with limit switches installed at the top and bottom of the renewable alloy roller track.

improvements in melting practice and foundry methods. Standard specifications now call for high duty cast irons with tensile strengths up to 40,000 to 50,000 lb. Along with this increased strength there has been a great deal of improvement in grain structure, density and wear resisting. (12)

NICKEL ALLOYS continue to be used in greater quantities and to become more diversified in their fields of application. Nickel is an influential constituent in a variety of alloys used for all kinds of machinery and equipment. Recent trends include increasing consumption of stainless steels, expanding use of nickel molbydenum steels for highly stressed parts, and of nickel cast irons for pressure components and parts subject to heat, abrasion, wear and corrosion.

The wide range of properties obtainable by varying the nickel-iron ratio in ferro-nickel alloys is being utilized in a number of fabrications, although the bulk of the ferro-nickel alloys produced are still of the Invar type and are used largely in thermostatic bi-metals. A high nickel alloy, containing also cobalt, aluminum and iron has been developed for permanent magnets. It has a high coercive force. Because of their special properties, the use of magnets of this type permits of unusually compact design and many devices formerly manufactured with wire wound magnets are now being built of permanent magnets of this type.

A non-ferrous heat-treatable nickel alloy has been developed which has in certain forms a tensile strength as high as 250,000 lb. per sq. in. and hardness values up to 46 Rockwell C. The alloy retains all the corrosion resistance and other properties of nickel.

Most of the big new planes built within recent months are equipped with exhaust manifolds and cabin heaters made of a high nickel-chromium alloy which has been found exceptionally successful in resisting the heat and corrosion encountered in this type and field of service. (13)

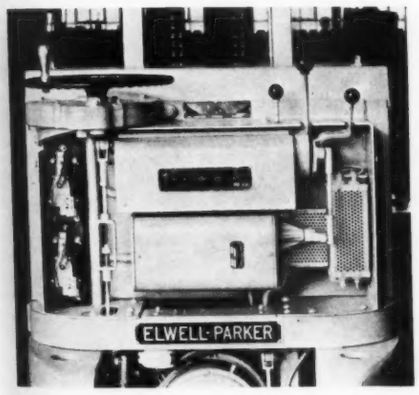
BRONZE BARS either cored or solid which are made in electric furnaces that are practically hermetically sealed, thus eliminating oxidation of the metal, are now available in a variety of mixes to suit the speed and load. Bars may be procured with Brinell hardness ranging from 45 to 75, with elongation ranging from 14 to 16 per cent and with 13,000 to 15,000 lb. per sq. in. yield point. (14)

LEAD-BEARING ALLOY BRONZE of the sintered type for bearings has been developed. By means of a pre-alloying process the lead is introduced. Its advantage is that it eliminates harshness and increases conformability for mis-alignment. The process reduces all the basic metals to one definite alloy thus creating a uniform grain structure and a thoroughly homogeneous material. In the manufacturing process, a definite amount of volatile material is included which later produces a porous structure in the material. By submersion in vacuum tanks the pores are filled with a high-grade oil of a viscosity to suit the application. Oil up to 35 per cent by volume is retained. The capillary structure of the bearing permits a constant flow of oil to the journal as needed. The material is recommended for bearings where lubrication is infrequent or where too much lubrication is likely to cause seepage that might damage the goods in process. (15)

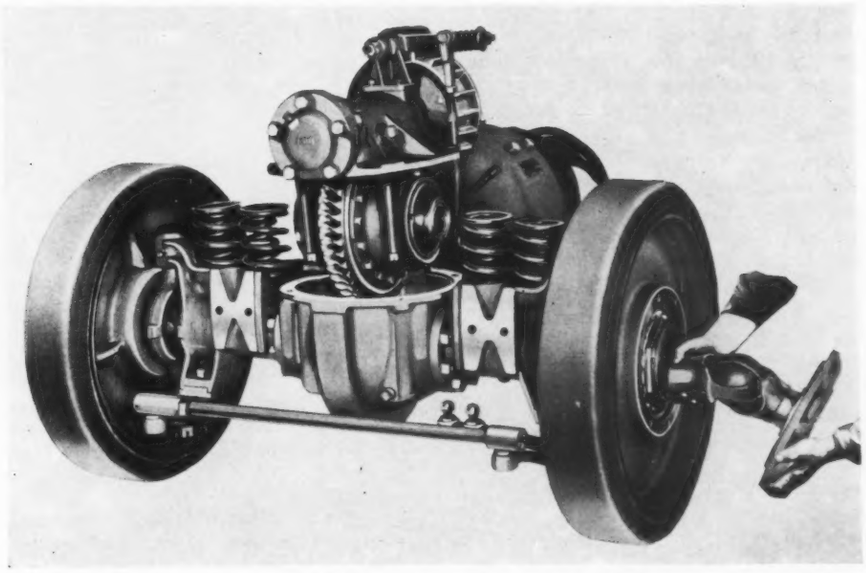
SELF-LUBRICATING BEARING METAL has been developed by a process that makes it possible to combine in a solid body pure metallic lead and copper, without in any way affecting the individual characteristics of the two metals. This is not an alloy and is technically described as a solidified emulsion of lead in copper. The structure is a copper matte having its interstices filled with amorphous virgin lead. The lead is, therefore, available as a lubricant. The copper acts as a heat expellant as well as the supporting medium.

The process used to make this material

. . . . . *As Used in Elwell-Parker Truck*



Controller provides four speeds forward and four reverse. The power circuit is closed and opened with a mill-type, magnetic blowout contactor which is electrically interlocked with the travel controller. Drums rotate on ball bearings and the fingers and finger tips are reversible and interchangeable. An oversize commutator takes excessive overloads which are encountered in industrial materials handling without overheating. Thus no fuses are required in the motor circuit, and additional safety in operation is assured, since fuses blow when greatest demand exists on grades.



Drive unit features drop forged alloy steel parts. Universal joints are forged from chrome-vanadium steel, heat-treated. Drive shafts are heat-treated chrome-molybdenum steel. Free coasting type worm engages a phosphor-bronze worm wheel mounted on a drop forged steel differential cage on centerline of truck. Four differential bevel pinions have internally ground surfaces, and are made from carburized, double-quenched nickel steel. A heat-treated drop forged carburized differential cross supports the pinions. Both pedals are interlocked with the drive controller; one closes the power circuit, the other operates the brake.

permits the copper and lead to be used in any desired proportion. By proportioning the lead and copper, various grades are obtained, each grade being best adapted for specific purposes. Several grades are suitable for bearings, the choice made being dependent on the speeds and the loads encountered. Other grades are suitable for electric motor and generator brushes, and some for metallic packings which are exposed to high temperature and pressures. It is claimed that bearings made of this material cannot score or damage a steel shaft or journal even though loaded far beyond its bearing capacity.

This bearing metal is suitable for operating in hot atmospheres such as baking and drying ovens, or locations where bearings are subjected to radiated heat or hot gases. They will operate at temperatures up to 1,200 deg. F. because the inherent lubricant is metallic and is not affected or destroyed by heat at that temperature. The material can be used for bearings in hydraulic machinery where flowing water would quickly dissipate lubricants.

Bearings made from this material are recommended for textile, food processing and packing machinery where lubricants would ordinarily contaminate or injure the product. It is also recommended for sliding and reciprocating parts working on contact with steel guides, such as elevator guide shoes, engine cross heads, brake shoes, machine slide gibes, thrust bearings and especially sliding parts operating vertically where lubrication would be difficult to maintain.

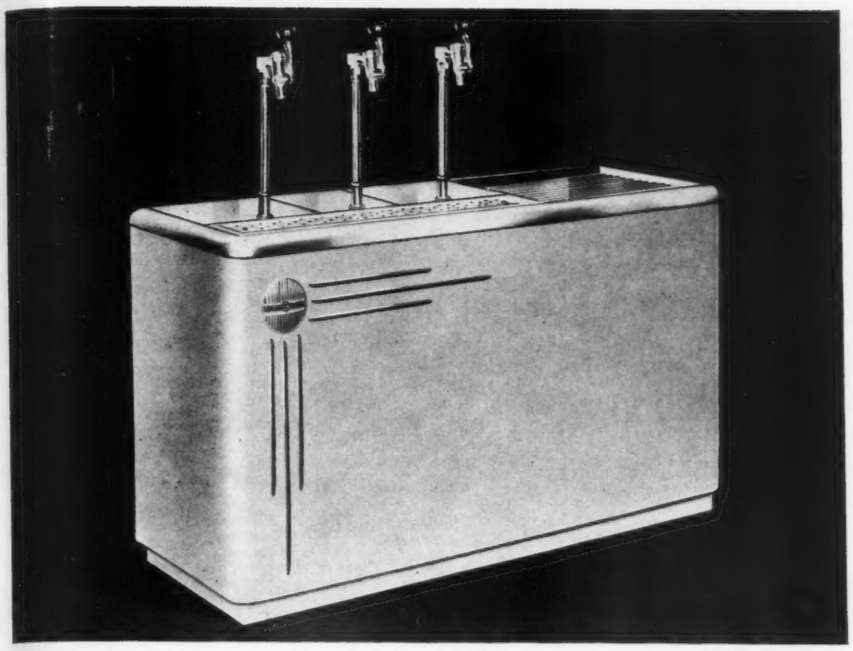
In mounting bearings made of this material, adequate backing should be provided to prevent distortion of the bearing bushing. The supporting ability of the metal when used as a bearing surface varies from 2,000 lb. per sq. in. for heavy loads at low speeds to 150 lb. per sq. in. at extremely high speeds. The material is easily machined and no cutting lubricant is needed. The material is available in solid bars ½ in. diameter and larger in 12 in. lengths, in cored bars of 1 in. inside diameter and larger, and in any shapes to pattern or form that can be sand cast. At least ⅛ in. should be allowed for finishing as only virgin metal will make a satisfactory bearing contact. (16)

NEW NICKEL ALLOY has been introduced which combines corrosion resistance of nickel with the mechanical properties of heat-treated steel. The alloy has a strength from two and a half to four times that of ordinary structural carbon steel. It has been produced with a tensile strength as high as 250,000 lb. per sq. in. and hardness values as high as 46 Rockwell C. In its unhardened, or annealed condition, it fabricates almost as easily as pure nickel. Such operations as bending, drawing, machining, and hot forging are accomplished readily. The metal can be heat-treated after fabrication with little distortion since heat-treating operations are carried out at low temperatures. While the commercial production of this alloy is too recent to indicate its industrial possibilities, it has been used for hand tools, wire brushes, spring clamps, spring coils, and a variety of electrical applications. (17)

NICKEL CLAD STEEL PLATES are now available in larger and thicker sizes, making possible their use in the construction of massive pressure vessels, evaporators, storage tanks, railroad tank cars, and other types of equipment. Such plates provide a pure nickel inner surface, free from the disadvantages of thin, loose linings that have the tendency to collapse when the vessel is under vacuum. The bond between the two metals gives the clad plate heat conductivity equal to that of solid steel plate, and maximum thermal efficiency is obtained in all equipment requiring heat transfer through the wall. The thermal coefficients of expansion of nickel and steel are nearly identical, and temperature changes within the range where nickel and steel may be used do not affect the bond. The choice of nickel-clad steel plate to meet particular corrosive conditions is governed by the expected behavior of pure nickel. (18)

COPPER-SILICON ALLOYS during this last year have been used in a wider range of applications. The copper-silicon-tin and the copper-silicon-manganese groups of alloys combine high strength and excellent physical properties with a high resistance to corrosion. Their strength is comparable to that of pure copper. These alloys are non-magnetic, they hot work readily and can be successfully welded by any of the standard commercial methods of gas or electric welding. When work hardened to give maximum tensile strength and hardness these materials can be heat-treated to relieve internal stresses without any sacrifice of either strength

Highly polished 18-8 stainless sheet is used for the body of this heavy-duty restaurant and hotel gas range, product of the American Stove Company. Cooking surface is alloy cast iron; door hinges are malleable iron. Oven has block insulation



Newly-developed compact beer dispenser, product of General Electric Company, has the self-contained G-E refrigerating unit housed in a cabinet of heavy-gage, rust-resistant galvaneal steel, finished with two coats of baked-on green enamel. Stainless steel is used for cabinet trim, and for the bar drain tray. Faucets are chrome-plated

or of hardness and with a distinct increase in elastic limit. The heat-treatment enables the metal to be used in a condition of maximum strength without the risk of stress corrosion cracking. These alloys are recommended for applications not only where copper would present an adequate resistance to corrosion, but also where high strength, ready weldability and other physical characteristics of the alloy render it valuable as a structural material. This alloy is adaptable for many parts where strength and resistance to corrosion is desired such as bolts, nuts, turnbuckles, lag screws, and screw machine parts. (19)

COPPER ALLOYS are being used in increasing quantities in the manufacture of parts by the hot forging process. Ease of fabrication and excellent physical properties are the chief reason for the wider use. A special forging brass has been developed for hot forging that flows readily at a reasonably low temperature. A silicon aluminum bronze has also been developed which forges easily in comparison with copper and the high copper bronzes. The hot forging process, it is claimed, has many advantages. The metal, softened by the forging temperature, can be formed with much less effort than is required for cold heading. For heavy-walled parts, that must have high strength, hot forgings are displacing bulkier but weaker sand castings. (20)

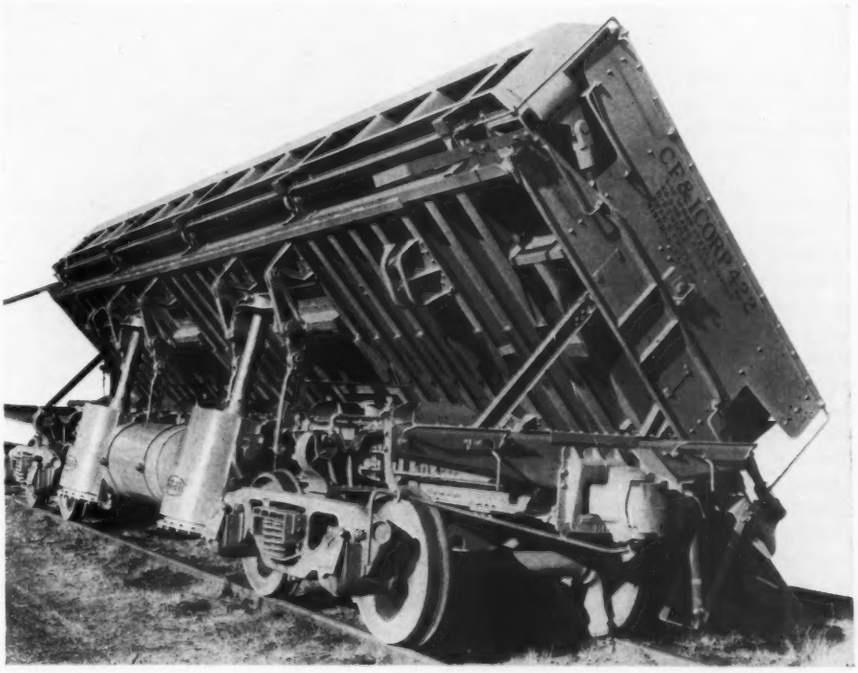
X-RAY PICTURES reveal defects in castings which are not perceptible to the eye and that would be hard to discern even with mechanical testing equipment unless the casting was destroyed. A manganese steel foundry reports that they are using the X-ray to detect flaws in castings. They have installed a 400,000 volt X-ray laboratory which has proven itself invaluable in cutting maintenance costs, preventing casualties from defective castings and assuring customers sound castings.

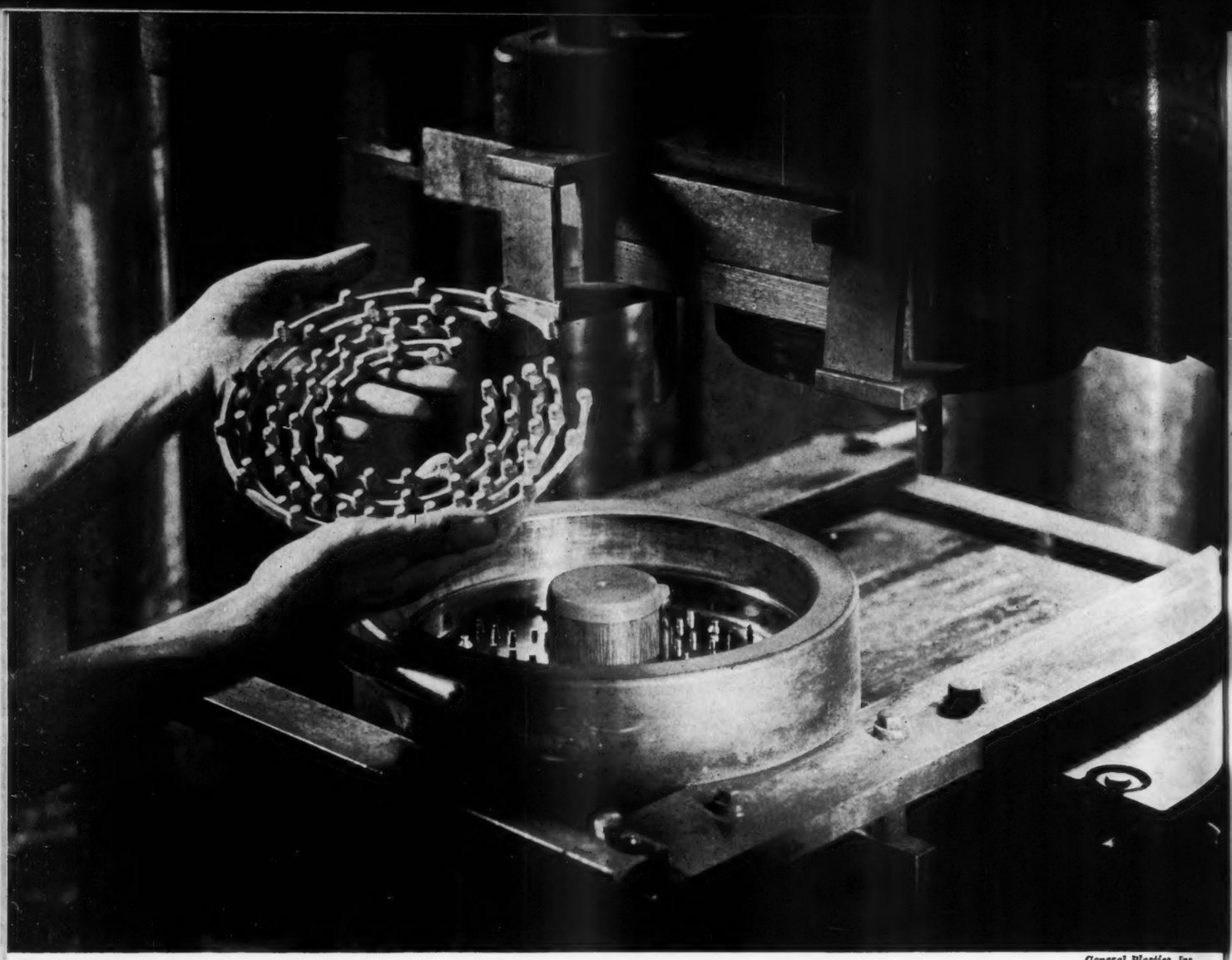
MAGNESIUM BASE ALLOYS which weigh two-thirds as much as aluminum and one-fifth as much as steel are being used for parts where light weight is an advantage. Castings are close grained and uniform. (21)

Welding Fabrication Reduces Weight 12,000 Lb.

Arc-welded alloy steel is used throughout in the construction of the Austin-Western 30 cu.yd. railroad dump car. The frame is built up of standard structural members of high tensile steel, consisting of angles, channels and plates cut to size, assembled to fit the design and fused together by electric arc welding. Pneumatic cylinder of the dumping mechanism of arc welded steel supersedes an iron casting.

Reduction of dead weight from 69,000 lb. to 57,000 lb. reduces motive power of hauling unit required, since a 6-car train of the new cars weighs less than a train of 5 cars of the previous type. Additional features include rubber shock absorbers, single-stroke cylinders with automatic shut-off valves, and a single dumping control which permits air to be applied to only one side of the car at a time.





General Plastics, Inc.

NON-METALLIC MATERIALS

PLASTICS. During the last two years with production problems more completely solved, more time has been devoted to the improvement of plastic materials themselves, usually in the laboratories of the manufacturer. Not only have there been great improvements in materials, but there also have appeared many new plastics which have increased the scope of plastic applications. In the phenolic group there has been a definite increase in the range of plasticity of the different molding compounds. Today, soft materials which once required long cure are available in the same plasticity but will cure much faster. Today cures as low as 30 seconds have been successfully used in high production runs.

After a great deal of research manufacturers have formulated a phenolic resin material which has excellent flexibility. In the past it had been necessary to remove threaded objects from the mold by hand. Parts made with this new material are stripped from the mold without damage to the piece, provided the stripping takes place while the mold and material are still hot. As soon as the pieces cool they set to the original form of the die without showing distortion.

Many new materials withstand harder buffing and polishing without breaking down and revealing the filler. Denser blacks are available through the use of improved dyestuffs and pigments. In the phenolic group better colors are now offered.

One of the major criticisms of the phenolic material was its lack of high impact strength. Within the past few years molding compounds have been offered which have from four to five times greater impact strength than any standard phenolic formerly on the market. These shock resistant materials have been used for many industrial applications which, until then, had been definitely considered as beyond the scope of molding compounds.

An improvement in phenolic resins which is of vital importance to manufacturers of radio and television apparatus is a new material that has very low loss or power factor, less than ½ per cent. One plastic manufacturer rates it at 0.34. While it is important in standard radio parts production because of the high frequencies employed, around one million cycles, it is readily seen that the extremely high frequencies used in television, fifty to sixty million cycles, demand just such a material as this for economical production. The new materials which are finding ready acceptance for jackets of radio condensers show a volume resistivity well up into the millions of megohms.

Recent improvements include the evolution of materials with non-bleeding properties. Plastic caps for liquor bot-

tles demand a non-bleed material that will not give off color or discolor upon contact with the alcoholic contents. Improvement in manufacturing of odorless phenolic resin material has helped in this field.

One manufacturer has formulated a new compound that is almost a new structural material. The material is almost wear-proof, and is exceptionally resistant to mild acids and alkalies and has the lowest specific gravity of any phenolic available today. This material was developed for use in the production of rayon. Miles of thread constantly pulling through a molded piece and sliding over another which is submerged in a chemical solution seem to have almost no effect on the surface of the piece. Yet if such a molded piece becomes disengaged from its shaft it will float to the top of the solution, because its specific gravity is so low.

Many new plastics of other groups, that is the ureas, cellulose esters, methyl methacrylates have also been advanced to a large degree. The range of light fast colors have been increased along with the translucency. Cellulose acetate materials are now being used in large volume.

Much credit should be given to the manufacturers of plastic production equipment for the rapid strides they have made in keeping up with new materials, furnishing better testing and production machines, automatic dies, and improved molding presses. Without their consistent effort in promoting new methods the material manufacturer would not have advanced to his present position. Plastics and plastic molding have been developed to such a degree that complete engineering data is now made available on hundreds of types of plastic material. Furthermore, the plastic manufacturers' laboratories have developed and formulated many new molding compounds to do specific jobs and meet new problems (22)

PHENOLIC MATERIALS continue to meet the exacting requirements for impact resistance, heat resistance, chemical resistance, and the many other essential properties that have opened up extensive markets for these products. Phenolic plastics because of the combination of properties and characteristics available continue to be popular in industry. A few phenolic compounds can now be had for injection molding operations.

Realizing that no single type of material will fulfill all the requirements of industry, one manufacturer of plastic molding materials has extended his line to include urea molding materials that are thermal setting and that are adapted to the same type of molds employed for phenolic materials. They differ from the phenolic in that they have excellent light resistance. Delicate pastel shades remain unaffected by exposure to light over long periods of time. A depth of luster gives a sparkling, rich appearance. In addition to ivory and white, urea molding materials are also available in an extensive range of brightly hued colors, in translucent as well as opaque effects. Molding characteristics are good and in general breathing or gassing of the mold is not necessary.

Automatic Radio Manufacturing Company's Tom Thumb midget radio has a housing fabricated of phenol-formaldehyde by the Plastic Turning Company. The high dielectric properties of cast phenol-formaldehyde, its non-inflammability and good acid resistance made it suitable for this application. Molding has fine luster

Plastic molding materials are now being made from polystyrene materials, which as electrical insulators provide excellent insulation value for high frequency circuits, having a power factor of 0.0001 to 0.0002 at 1,000 cycles and less than 0.0002 at a million cycles. These materials resist concentrated sulphuric acid and concentrated alkalis. Their resistance to water is good. The material is strong and light in weight, having a tensile strength of 3,000 to 5,000 lb. per sq.in. and an impact strength (energy to break) of 0.14 to 0.16 lb. The material is thermoplastic and parts molded from this material have good dimensional stability at normal temperatures and because of low molding shrinkage can be formed with accuracy. This group of materials can be molded either by the older compression molding or by the newer type injection molding machines. The natural color of this product is almost water-white, it is available for commercial use in various colors.

To meet the demand for transparent thermosetting phenolic molding materials that could be molded in the conventional compression molds, several types of transparent phenolic molding materials have been developed. Molded parts produced from these materials have a depth of color and are transparent. Other properties also include hardness, heat resistance, dielectric strength, dimensional stability and lightness in weight. (23)

AUTOMATIC MOLDING advances have furthered the development of faster curing phenolic compounds. A new material has been designed for relatively small parts which, when used as a closure material will cure in 35 seconds. This material is not adaptable to large moldings. In addition to fast curing the material is said to be non-bleeding, odorless, and has a good finish. (24)

NATURAL WOODS impregnated with plastic molding compounds have recently been announced. They are said to be tough, long wearing and to possess the durability and hardness of plastic molded material along with the varied beauty of genuine wood. This product is available in the popular wood designs, mahogany, oak, walnut and pine. The wood finish is not an imitation but is the natural wood so impregnated and treated that a glasslike surface is produced. It is impervious to liquids of all kinds, yet it will not chip, break or crack. The material is furnished in sheets 48 in. x 96 in. It can be cut with an ordinary carpenter's saw to any desired specification, or quickly drilled for attaching. It is stated that it will not warp or spring when it is properly applied. It does not require resurfacing. (25)

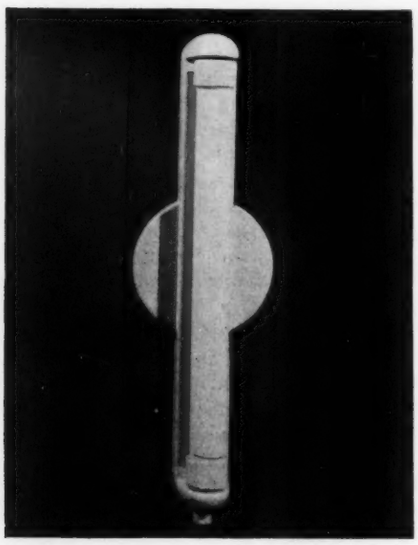
TRANSPARENT PLASTICS of the cellulose acetate type have been developed for air-

craft windshields and cockpit inclosures. They have been found to be suitable for the purpose after rigid weathering and exposure tests conducted by a large nationally known laboratory, specializing in the testing of aircraft plastics. (26)

TRANSPARENT PLASTIC material has been developed which has found application in making reflector buttons for use on highways to mark the edge of the road, for signs, and similar purposes. It is stated that when placed at 100 ft. intervals along the edge of the road these reflectors reflect the light from one's headlamps and clearly outline or define the highway for a full half mile ahead of the car. (27)

CELLULOSE-ACETATE molding materials that are thermoplastic and suitable for injection and compression molding have recently been announced by a manufacturer of plastic molding compounds. These materials have excellent surface luster and are furnished in a wide range of colors, in opaque, translucent and crystal clear transparent effects, as well as mottled or variegated colors. Molding properties and finished characteristics may be varied to suit a diversity of specific uses. (28)

COATING DIE-CASTINGS with plastic materials by means of the injection molding process has been done to eliminate metal finishing operations and also to impart desired colors to products. Often additional weight is wanted in a plastic piece as well as strength and rigidity. This process helps to obtain both objectives. Parts may be cemented together or fastened with screws inserted in tapped holes in the die castings. (29)



Molded of urea-formaldehyde, this one-piece Lumiline lamp bracket, designed by the Holden Company, is claimed to be shock-, corrosion- and chip-resistant. The fixture is available in black or ivory

UREA FORMALDEHYDE plastics for use in mechanical parts and as large precision moldings have made considerable progress in the last year. Some of the improvements made in these materials are greater ease of molding, increased flow characteristics, and the control of plasticity to permit the molding of thin, deep draw sections with resultant betterment in the uniformity of strength, structure and surface. New colors have been added to give these materials a complete range for almost every variation in value and intensity. A few new applications for which these materials have been used are: lighting reflector bowls, multiple section housings for such mechanical products as scales, appliances and radios. Electric appliance housings, clocks, range timers, and thermostats are other products which find these molding materials satisfactory for housings. (30)

The new Rand shaver has a housing of molded urea-formaldehyde, of high dielectric strength, resistant to perspiration, oils and rough handling; plus the necessary physical properties. A feature of the Rand shaver is the complete elimination of rotating parts in the motor

SYNTHETIC BRISTLES have been recently developed that assure absolute sterility. It is claimed that the new synthetic bristles are superior to natural pig bristles in uniformity, appearance and durability. These bristles are intended to be used in the manufacture of brushes. Yarn made from the same kind of synthetic material as developed for brush bristles is said to produce hosiery that more nearly resembles silk than does rayon. It is said to last much longer, possess greater wearing properties and have greater elasticity. (31)

CAST RESIN PARTS as long as 34 in. are now available because of new developments in producing steel molds from which lead production molds are made. These parts are produced in two piece slush molds made of lead. With this advancement almost any kind or shape of casting can be made, including pieces having cup shaped sections, also a great many surfaces having reverse tapers or draft. (32)

INSULATING CEMENT that can be cast and that will withstand temperatures up to 2,000 deg. F. has been developed. It is suitable for casting light doors for heat-treating and annealing furnaces, and for completely insulating annealing furnaces, forge furnaces, oil tanks, large pipe coverings and fittings, and chemical units. It must be applied to a cold surface and allowed to stand for 72 hr. before applying heat. After this insulation is cast, a refractory is poured on top of it to complete the thickness of the lining and to knit the entire mass together which then dries into a dense monolithic lining free from joints. (33)

CELLULOSE ACETATE laminated safety glass sheeting material has been developed which greatly increases the strength of laminated safety glass, particularly at low temperatures. (34)

GLASS-LINED KETTLES heated by electrical immersion units that will maintain temperatures up to 500 deg. F. are being used in the manufacture of varnish. Along with the advantage of controlling temperature exactly, metal oxides are eliminated to prevent discoloration, closed glass-lined kettles also retard oxidation. The new type of kettle requires about one-sixth of the floor space that is required by the old type open-fired kettles. (35)

WOVEN GLASS FABRIC used in place of paper or cloth as a base for a new laminated plastic material is reported to have good resistance to the action of corrosive liquids. Electrical character-

A new reflector, 12 in. in diameter, molded of urea-formaldehyde by the Waterbury Button Company, can be screwed into any overhead socket; it is light in weight and heat-resistant

istics of the material are reported to be excellent when dry. (36)

WOVEN GLASS TAPES and braided materials for electrical insulation are now competing with cotton tapes. The glass tapes are woven from yarn consisting entirely of glass fibers. The fibers are of extremely fine diameter which gives the yarns and tapes the requisite degree of flexibility and softness. The fineness of the fiber is also responsible for the high tensile strength of these tapes since the glass fiber strength is approximately 150,000 lb. per sq.in. The glass used to make these tapes is hard and is alkali free which makes them chemically neutral as well as imparting to them a high electrical surface resistance. A small amount of lubricating composition is added to improve the weaving and handling property of the glass yarns. The tape has selvedge edges and is of a plain weave which is sufficiently open to permit the ready penetration of the various electrical varnishes used in the impregnation of coils. When the tapes are impregnated with electrical varnish they are highly impervious to moisture. They resist the attack of moisture, corrosive gases and other agents which tend to cause deterioration of insulating materials. The dielectric strength as in other fibrous materials depends upon the impregnation used as well as the quality of the fibre itself. The use of these glass tapes is recommended for the insulation of electrical conductors where ability to withstand high temperatures is desired, also where non-inflammability is desirable, or where moisture, corrosive fumes, or other severe conditions are encountered. (37)

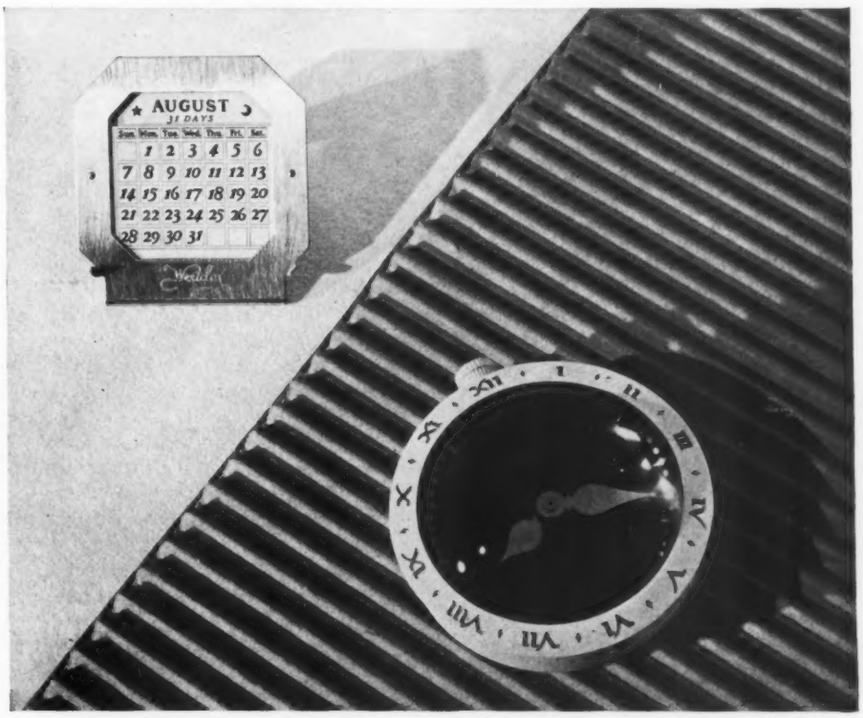
SOLID GRAPHITIC MATERIALS have been developed which do not shrink or expand, that are chemically inert, heat-resistant, mechanically strong, non-magnetic and easily machined. The materials can be used for clutch release bearings, seal rings for compressors, small pistons, mechanical seals on water pumps, annular bearings, thrust bearings, flexible joint seal rings handling steam or liquids, electrical control contacts, friction blocks on brakes or friction clutches and blocks or plates for conveying hot glass. (38)

FELT PRODUCTS manufacturer reports that his experimental laboratory has been kept busy with new finishes and applications of wool felt. A new development is a special finish on wool felt which makes possible a permanent and clear-cut molding to required shapes. Another development is an improved gasket material which is a resilient felt reinforced with sheet gasketing for water, oil, air and steam lines, this material can also be molded to special shapes. Laminated felt and synthetic rubber cut into strips and washers is available for oil retention in which the felt acts as a lubricating wick and the synthetic rubber prevents passage of oil. The material is recommended for heavy machinery. A special felt has also been designed for sound and vibration dampening. A flameproof wool felt of light weight has been perfected for heat and cold insulation (39)

FELT during the past year, it has been reported, has been used in a greater degree for isolating vibration in individual machines, especially when new machinery was installed or where new equipment or new unit grouping in a factory necessitated a realignment of machines. (40)

RUBBER-LIKE GASKET material which possesses permanent resiliency has been placed on the market. It is impervious to water, oil and other penetrating liquids ordinarily destructive to gaskets. It does not permit seepage or capillary action. After the gasket has been cut it is encased in a film of rubber-like material which seals all exposed surfaces and edges. The surface is flexible and will conform to uneven metal surfaces. While this material will withstand high temperatures it is not intended for such extremes as those generated in the manifold and cylinder heads of engines. It should have wide application in all industry both as standard equipment and replacements for automobiles, stationary motors, and industrial engines where a perfect seal against leakage of penetrating liquids is necessary. (41)

PAPER BASE SHEET material that has been treated with phenolic varnish is now available. It is offered as punching stock to meet various requirements. The material is furnished in five standard grades. One grade, that is the toughest and most flexible as well as resilient, is recommended for riveting operations. This material can be forced over a fluted shaft, or can be stamped with letters without cracking. It can be punched cold with a smooth edge in thicknesses up to 1/16 in. It is so flexible that a piece 1/32 in. in thickness and ½ in. wide can be bent with the grain to a ½ in. diameter arc. The moisture absorption for 1/16 in. thick stock after 24 hr. immersion is 4 to 8 per cent. Another grade is recommended for general purpose cold punching. It can be punched or sheared cold in thicknesses up to and including 3/32 in. The average moisture absorption of this grade for 1/16 in. stock after 24-hr. immersion is 4 per cent. Another grade, primarily designed for use in radio frequency circuits has for the 1/16 in. thickness the following approximate characteristics: loss factor at 1,000 kc., dry, is 0.08, water absorption 24 hr. immersion is 0.8 per cent. Loss factor at 1,000 kc., after 24 hr. water immersion is 0.085. This material can be punched hot in properly constructed dies up to and including 1/16 in. thick. (42)



Heavy, pressed-glass lens is held on case by a cellulose-acetate molded bezel which also serves as numeral dial in this Westclox desk clock. Cellulose acetate is used because of its strength and toughness, and good quality, color and finish. Winding stem button is also of cellulose acetate. Rear of case is felt cushioned. The pressed glass is polished on the underside and fire-polished on the convex side

Westinghouse Electric & Mfg. Co.

MECHANICAL PARTS

REFINEMENTS have been numerous in the design of mechanical parts and machine elements, that are supplied as units ready for assembling into or mounting on machines, appliances and equipment for specific purposes. This review does not attempt to cover all the improvements and new designs which have been announced during the past year. However, an effort has been made to describe tersely new developments that indicate new influences and possibilities in the design of mechanical parts and auxiliary units.

ELECTRIC HYDRAULIC standardized control units have been developed into quite a wide line for certain specific applications. Usually the reason for introducing electrical control with the hydraulic control is that the process or the work is of such nature that it is most easily timed or measured by some electrical device. If the installation is a very large one, or if it is more convenient to use electrical control in conjunction with the hydraulic control, rather than a full hydraulic operation by pilot lines, it is important that reliable apparatus be used. Solenoids can be used to actuate hydraulic control valves, and it is, therefore, possible to transmit a timed electric impulse into a resultant hydraulic function which in turn is transmitted into the mechanical motion required. Panels are now available with either one or two solenoids integrally designed into the apparatus. A complete line of solenoid operated four-way valves has now been developed.

Other new electric hydraulic products include pressure switches. With the use of these various units in a circuit it is possible to get practically any sequence of operations or motions that the designer may require. All of these items are an addition to a full hydraulic control line of devices which are supplied for manual, mechanical, or hydraulic pilot operation. One type of solenoid operated traverse and feed panel is used for controlling rapid advance, adjustable feed rates and rapid return movements of a machine tool table or head. The hydraulic action within the panel itself is in turn controlled by cams or dogs on the table and also by two integrally mounted solenoids. Feed rate adjustment dials are provided upon the panels, with either one or two adjustable feed rates are available for use as required. A large variety of machine tool traverse and feed cycles can be obtained with a single standardized panel control unit, the variations in cycle being obtained by the use of various "T" slot cams and various electrical hookups with limit switches.

Solenoid operated four-way valves are also available in sizes from ½ in. to 2 in. pipe size. Hydraulic valves proper are also available in several types to

allow for various circuit requirements, and some models are used for tandem operation where large back pressures are to be considered. In addition there are types which are termed "gasket mounting" that mount directly upon drilled pads on the machine, thereby doing away altogether with exposed piping connections. In addition there are air-cooled and also oil cooled solenoids available. (43)

HYDRAULIC PUMP UNITS with the control valves built into the pump housing have been placed on the market by one manufacturer. The units are compact and are made in two sizes. The larger unit is a variable displacement piston pump which can be furnished with three different feed rates, fast, medium and slow, each of which is independently adjustable. In addition there is a constant volume pump which provides rapid traverse. Both pumps are driven by a single shaft. (44)

HYDRAULIC CONTROL VALVES of a new style for manual, hydraulic and electrical operation in the two-way, three-way and four-way types, together with reverse flow type release valves, have been placed on the market in the past two years. (45)

HYDRAULIC CYLINDERS of the double acting type without tie rods in conventional sizes from 2 in. to 8 in. in diameter with lug, foot or flanged mountings, designed for working pressures up to 3,000 lb. per sq. in. are now available for fluid power installations. (47)

COOLANT PUMP that is designed especially for a large volume of fluid at a low head, where dirt or abrasive material may be present in the liquid, is complete with a vertical motor which is fully inclosed and has grease sealed ball bearings as a protection against grit or other foreign substances. The stainless steel shaft is integral with the motor and the aluminum bronze impeller is the open or non-clogging type. The cast impeller-wheel is hydraulically balanced and is designed to allow abrasives to be discharged without excess wear within the housing. (48)

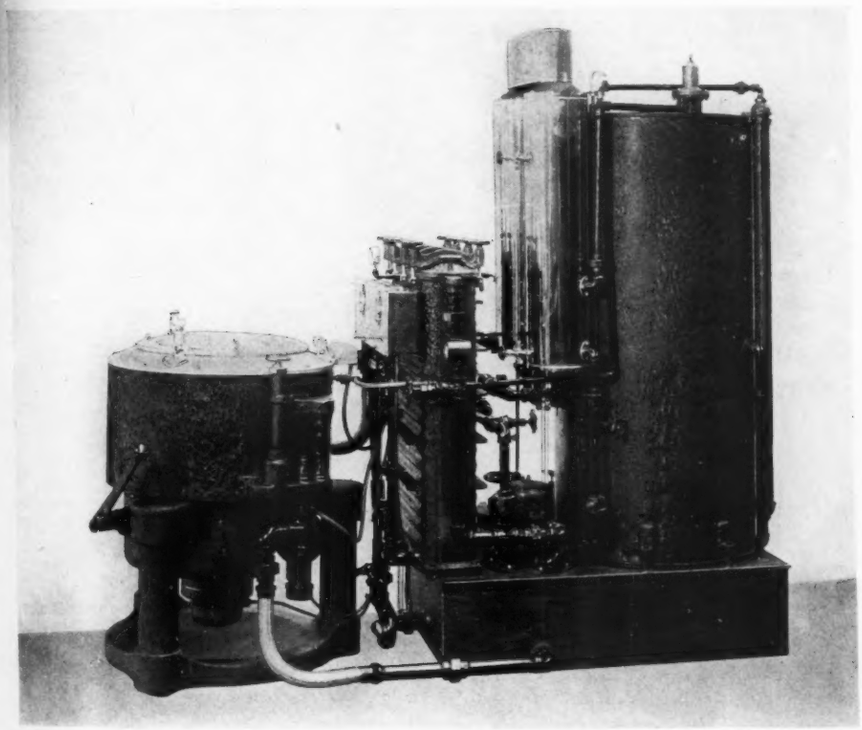
THREADLESS PIPE FITTINGS for pressure service, are now on the market which require no threading on the pipe. At each end of the fitting body are nuts which when tightened compress a resilient rubber-compound gasket around the end of each pipe. To install, the end nuts are loosened and the plain pipe end is slipped in. These fittings, when used, give flexibility to the pipe joint and afford protection against vibration, expansion, contraction and other stresses in the pipe line. These fittings have bodies and nuts made of certified malleable iron and conform to specifications for the 150 lb. malleable fittings. The line of fittings is recommended for use with working pressures up to and including 150 lb. per sq. in. Exact pipe lengths are not necessary as the fitting body spans the variations in space between the pipe ends. (49)

MULTIPLE OIL FILM carries the load in new bearing thereby preventing metallic contact and wear. The special construction is said to eliminate vibration and noise. Lubrication of the bearing surfaces is accomplished by the bearing itself acting as a centrifugal force feed pump. These bearings are designed for applications such as electric motors, pumps, blowers, compressors, conveying machinery, steam turbines, turbo-blowers, centrifugal pumps, grinders and boring machines. (50)

BALL BEARING CARTRIDGES for converting sleeve-type motors into ball bearing types have been developed in three different styles. A heavy duty design has been developed particularly for electric motor application which is merely bolted into the end bell of the motor. A flange type is offered for the convenience of users who wish to do the minimum amount of machining that bolts through the flange into the frame of the machine. A cylindrical type is also supplied which can be mounted as a unit that fits in a straight bore with a push fit against a shoulder in the housing. (51)

A BALL BEARING, mounted in a cartridge unit which consists of an inner and outer steel ring between which is inserted and vulcanized a synthetic rubber ring, is used by a manufacturer of floor sanding machines. The sanding drum shaft which is driven by a V-belt revolves in the synthetic rubber mounted ball bearing so that the drum can follow the surface of any floor without bearing strain. This assembly affords a flexible mounting which will either support the bearing through suspension or under compression. (52)

RUBBER PILLOW BLOCKS fitted with ball bearings are finding applications in the heating, ventilating and air conditioning field. The bearings at time of assembly are packed with sufficient grease to last for years. Where unusual conditions may require occasional renewal of lubricant, the housings may be obtained with a grease fitting. Integral steel plates form a shield and an effective closure through which no dirt can penetrate or grease escape. The housings are made of molded rubber into which the bear-



Threadless fittings are used in the assembly of the various service lines in the SEC dry cleaning machine of the Star Equipment Company. This machine cleans and dries sixty to seventy lb. per hour at 1½ cents solvent cost and 10 cents electrical energy cost. Distillation rate is fifty to sixty gals. per hour. The extractor is driven at 900 r.p.m. by a ½ hp. motor through a friction clutch operated by centrifugal force. The extractor is fully floating, vibration caused by unbalanced loads being absorbed vertically by pneumatic cushions built into the legs, and horizontally by the synthetic-rubber mounting caps in the top of the legs. Thus no vibration is transmitted to the floor; no special foundation is required

ing is pressed. Bolt holes in the housing are fitted with steel shells to prevent possibility of enlarging or tearing out. The units are provided with wire springs in the base for grounding any electrical charges which may be set up in the insulated bearing. The rubber housing insures silence of operation by insulating the bearing to absorb internal noise. (53)

FLEXIBLE COUPLINGS have been developed from time to time to meet special needs. One new type has a set of jaws in the form of a removable ring. This ring is held in place and driven by alloy steel cap screws. The jaw ring is so constructed that it is adjustable on the jaw body so that it can be positioned to set or time the cushioning action at definite points in gasoline, steam or diesel engine cycles. Another type designed to reduce the longitudinal space necessary to install a coupling has a plain body which bolts on to a flywheel, a clutch or a brake drum. (54)

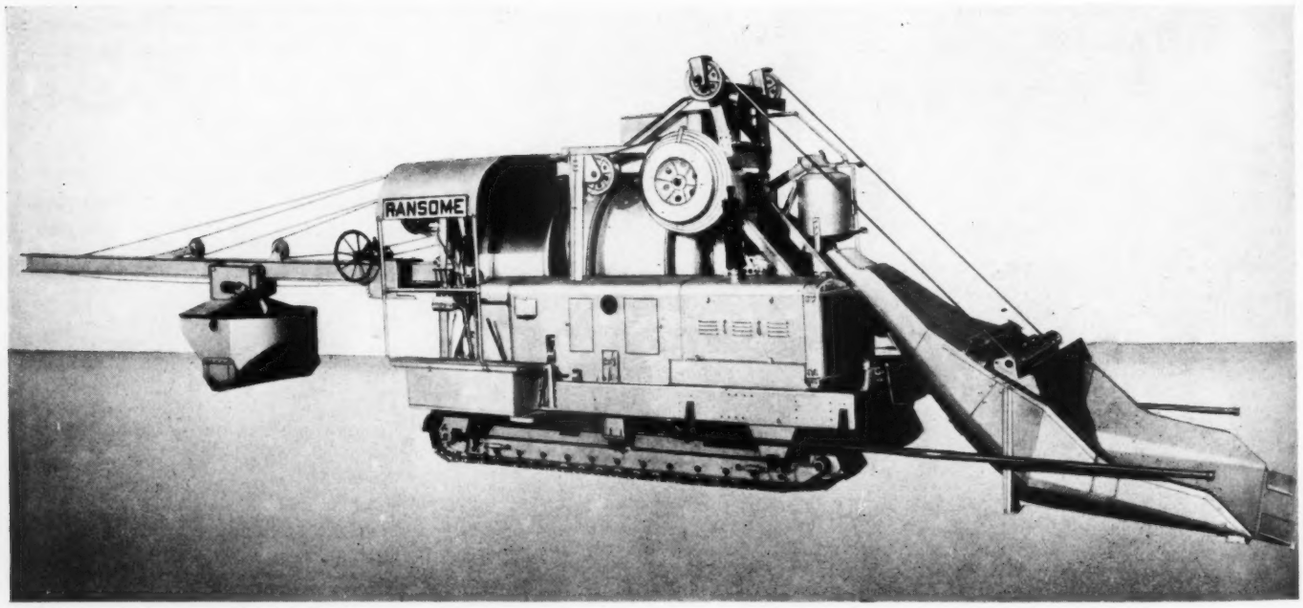
FLEXIBLE COUPLING designed on the Oldham principle uses a new type of non-metallic self-lubricating bearing strip on the center member. The metal center block in this coupling is equipped with special removable graphite-impregnated strips. The use of these strips supplement the lubrication provided by a lubricant in the center block of the coupling and tends to safeguard against any possibility of a lapse in maintenance. Also incorporated in this coupling is the use of a new special type alloy screw for rigidly securing the removable non-metallic bearing strips and safeguarding these from loosening. The screw may be removed at intervals either for renewing the supply of lubricant or for replacing the bearing strip without the danger of it becoming worn, thus insuring a secure attachment at all times. The center block is entirely metallic and is hollow to provide a reservoir for suitable lubricant, which is delivered to the wearing surfaces through small holes. (55)

OVER-RUNNING CLUTCH for intermittent power applications during the last 18 months has been redesigned which is especially recommended for dual drives, two speed drives, ratchets and back stops. The housing of the clutch is forged steel, it is rigidly connected to a sleeve which can be joined to either the driving or driven mechanism. An accurately ground race of oil-hardened tool steel fits the inside of the housing. The internal mechanism, which serves to connect or disconnect the drive between the housing and the hub, consists of hardened and ground tool steel rolls held in position on flat surfaces of the hub, forming a circle and running between the hub and the race and the housing. The spaces between the flat surfaces on the hub and the curved surface of the outer race are in the form of acute angles with each roll touching both sides on an angle. (56)

AUTOMATIC SAFETY CLUTCH incased in a dust proof compartment with no outside operating levers has been developed for machine drives. The unit may be applied to a sprocket, a gear or a coupling. The housing of the clutch is usually bolted to the driving medium, and where a split shaft construction is desired, it is keyed to the driving shaft. The clutch is set for a predetermined load and will dis-engage instantly when any additional load is incurred. It is held out during disengagement by a lockout device, thereby eliminating any contact or friction during the coasting period. (57)

CLUTCHES with tapered parts have been used in transmission units for many years. However, this old principle is given a new twist in a clutch that makes use of tapered rolls that are free to float in two directions. These rolls when forced into engagement do not grip instantly, but are retarded just enough to relieve the motor or other prime mover from the sudden shock load. The sleeve that carries the rolls slides over a fixed

Ransome Dual-Drum Paver . . . . . .



Recently redesigned, the Dual-Drum Paver, manufactured by the Ransome Concrete Machinery Company, is equipped for hydraulic control of boom swing and automatic hydraulic operation of discharge chute, transfer chute and water tank valves. Dual-drums provide mixing of two batches of concrete at the same time with one drum one-half of a mixing cycle ahead of the second drum; production is increased 50 per cent or more per hour with lower paver crew costs per mile. Paver is powered by a 6 cylinder gasoline engine driving through a friction clutch and helical-gear speed reducer. Hoist drum shaft is ball and socket-mounted to avoid any binding that might be caused by possible distortion of the paver frame. Mixing drum and drum blades are lined with high carbon steel. Tracks of high carbon steel are welded around drum; entire drum is then placed in a lathe and the tracks machined to a perfect circle.

hub and is held in a locking position by toggles. (58)

FLEXIBLE SHAFTING is used for turning rotary units in radio apparatus making it possible to mount various units in the best position with respect to the circuit and yet have all the controls on a small single panel. The use of flexible shafting in such installations allows freedom in both electrical circuit and cabinet design with much latitude in positioning the controls. Flexible shafts also make it possible to place parts that are panel mounted in desirable positions. (59)

FLEXIBLE SHAFTING is used in an interesting application for operating a truck-trailer freight handling device, where a flexible shaft connects an hydraulic pump on the trailer to a power take-off on the truck. (60)

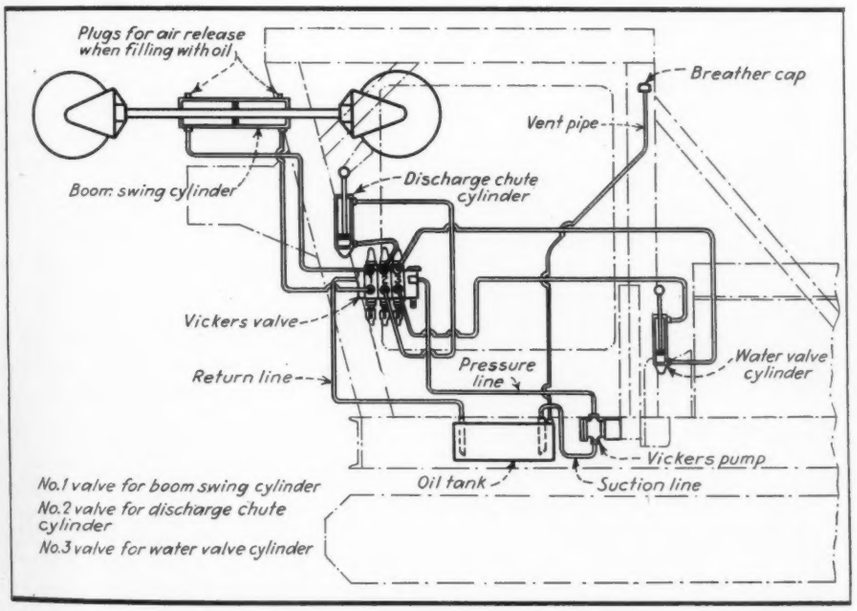
SPEED REDUCING DEVICES for many kinds of service are coming into more general use. One speed reducer recently developed has a worm located above the gear. The worm is cut integral with the high speed shaft. The worm gear is phosphor bronze and keyed to the slow speed shaft which is mounted on roller bearings. Special oil seals and drilled return passages eliminate all oil leakage. Designed for medium duty it is available in ratios from 8 to 1 up to 72 to 1 and in horsepower capacities from ½ to 5 depending upon the ratio speed reduction. Double reduction units are also available for transmitting torque loads of 300 to 800 in. lb. depending upon the ratio of reduction. These are furnished in standard ratios from 36 to 1 up to 1,800 to 1. The same manufacturer is now building a differential speed reducer which can be built for unlimited ratios of reduction, helical gears are used throughout, the shafts are alloy steel heat-treated to insure maximum strength and durability. (61)

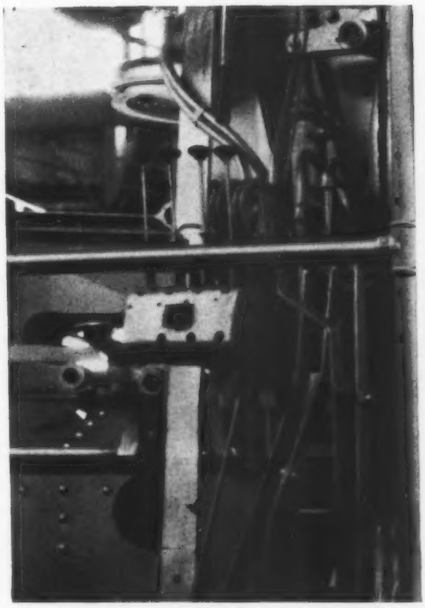
DIFFERENTIAL of new design consists of a frame in which there are three ball bearing mounted shafts. The two end shafts are arranged for connection to the driving and driven machines for any predetermined speed relation. The center shaft is connected to a shifting screw of the transmission and remains stationary as long as the predetermined speed relation continues. If one of the machines increases or decreases its speed in relation to the other, this difference in speed revolves the center shaft in the direction to correct the speed and bring both machines into the predetermined speed relation. The differential is completely inclosed in an oil tight casing or housing unit. (62)

VARIABLE SPEED PULLEY for motor drive employs an arrangement in which both driving disks are positively moved equal amounts in opposite directions when changing speed. This feature maintains the center alignment of the belt at all times, that is, the belt does not move sidewise. With this design the center to center distance between the driving and the driven shafts is maintained and a wide speed range secured. (63)

MECHANICAL AUTOMATIC control for a variable speed transmission unit has been developed which greatly increases the utility of the unit. The control provides automatic speed regulation that makes possible the synchronization of different machines and separate sections of a single machine, maintenance of constant tension and uniform peripheral winding speeds, and maintenance of uniform pressure, weight, liquid level, temperature and other variable elements. To an extended lever on the control is attached a cable, a chain, a float rod, or a pressure regulator rod running to the moving carriage or part of the machine from which indication of required speeds can be taken. Movement of the lever is transmitted to the speed changing mechanism of the drive to change the speed in accordance with the indicating movement, thus providing the advantages of

. . . . . *Hydraulically Controlled*





Eliminating 100 moving parts formerly necessary with mechanical drive, the hydraulic circuit on this paver provides smoother operation and better control with lower maintenance and replacement costs. Transfer chute automatically swings into mixing position before batch enters first compartment. As transfer chute moves into position to discharge mix into second drum, the discharge chute on the second drum swings into mixing position. Discharge and transfer chute can be stopped at any point of travel, and reversed. This protects against breakage and gives quicker release should aggregate become jammed.

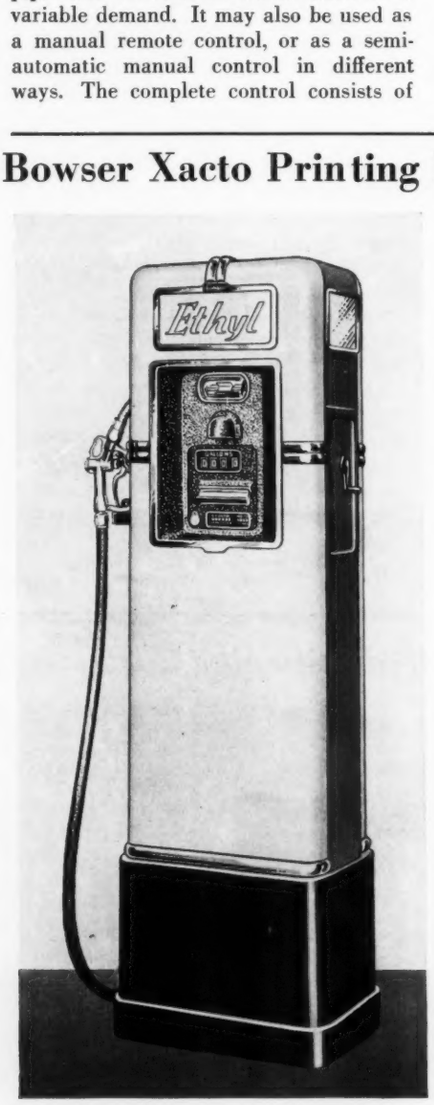
Hydraulic controls are grouped in a single panel for accessibility. Hydraulic operating pressure is maintained by an oil pump driven off the engine transmission shaft. Water tank valves open and close automatically. Boom is locked when control valve is in neutral. Skip and boom are mechanically controlled.

automatic control. The travel of the lever in either direction is limited by stop screws. The lever may be of any length and may be assembled in any one of four positions. (64)

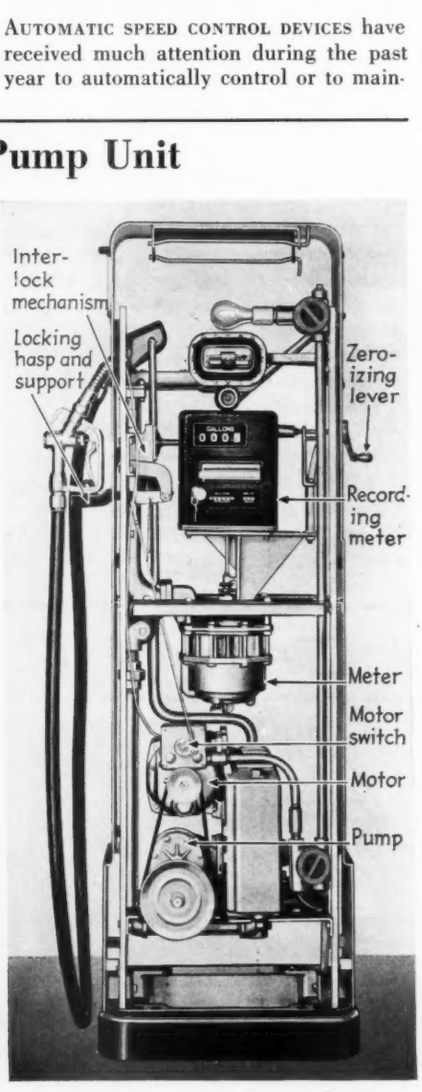
CONTROL for variable speed transmission devices has been reported that will automatically regulate speed from pressure variations in a fluid pressure source in a pipe line or tank in which there is a variable demand. It may also be used as a manual remote control, or as a semi-automatic manual control in different ways. The complete control consists of a bellows shifting mechanism mounted on the variable speed unit, an adjustable pressure reducing valve located where desired, auxiliary valves if needed and connecting pipes. The fluid pressure is transmitted by means of oil, water, steam, gas or air by a valve through piping to the bellows shifting mechanism which operates to increase or decrease speed on the transmission unit and hence on the driven machine. (65)

AUTOMATIC SPEED CONTROL DEVICES have received much attention during the past year to automatically control or to maintain a uniform tension on winding operations. The power motor, in one new mechanism, driving the transmission is mounted in a cradle carried by ball bearings in line with the center of the rotor shaft, so that the motor is free to oscillate within limits. The tension in the belt is maintained by adjustable weights mounted on the motor cradle. Any variation in the pull of the driving V-belts oscillates the motor in its mounting. The movement of the motor operates a rotary contactor. The rotary contactor controls the speed of the winding mandrel in proportion to the change in tension. In operation the motor stands practically in a fixed position oscillating just sufficient to operate the contactor. The outstanding feature of this contactor is that it is of rugged construction for especially high speed operation. All the parts move on ball bearings, all contact points are pure tungsten, there are no flexible leads or electrical connections to any of the movable parts. The time the contacts are in engagement is adjustable so that any thickness of material can be wound at a uniform tension. Sheet steel and similar products are wound on mandrels usually about 3 in. in diameter, and wound into rolls 30 to 50 in. in diameter. It is necessary that the material be wound at a uniform tension. With the controls described the transmission is operated at its fastest speed when the material is started on the mandrel. As the diameter increases the tension tends to increase, thus oscillating the motor and engaging contacts to reduce the speed of the mandrel in proportion to the change in tension in the material. (66)

Bowser Xacto Printing Pump Unit



Automatically-printed records of delivery are furnished by the gasoline pumping unit designed by S. F. Bowser and Company. A special interlock mechanism prevents the indicator from being cleared until a sales slip has been inserted; and numerals cannot be advanced or retarded during delivery. Motor switch is operated by a lever that has a locking hasp and serves as hose support. The unit has internal illumination for night operation, a positive-displacement Xacto meter, an air eliminator, and synthetic rubber delivery hose. Pump is driven by a V-belt from a standard 1/3 hp. explosion-proof motor.



Pump in the unit is of the herringbone gear type, with rotary seal packing box on the drive shaft connected to the suction port. Thus the packing box is subjected to vacuum instead of pressure. Shafts are nitrided steel running in cast iron bearings. Driven gear is 12 per cent semi-steel casting; the driver gear is S.A.E. X1355 steel, cut oversize 0.002 to 0.004 in. Gears for each pump are "run in" in pairs, before installation, on adjustable centers using a paste abrasive, then gasoline and finally oil. At no point between the gears, or the body and head is clearance in excess of 0.003 in.; this feature insures self-priming.

PUMPING UNIT that is used in a fuel dispensing pump that automatically prints a sales slip which verifies the amount dispensed, is fitted with gears of the herringbone type. The pump is self-priming and driven by a V-belt. The unit is driven by a Nitralloy shaft mounted in cast iron bearings. It is claimed that the herringbone gears offer less resistance to flow than a straight gear tooth, for when the teeth mesh the liquid is permitted to slide out naturally, that is, not squeezed out. - (*For other details see illustrations on this page.*) (67)

V-BELTS IN MULTIPLE drives should be all the same length if equal load distribution is desired since the shortest belt in the set is likely to bear the brunt of the power load. One company has developed a machine which matches belts precisely for its customers. When stocked by mill supply dealers, belts measured by the machine are marked for each 0.1 in. deviation from nominal length. (68)

AUTOMATIC OIL LUBRICATING is a necessity on many modern machines. To meet the current demand a pumping unit which provides flood plus controlled

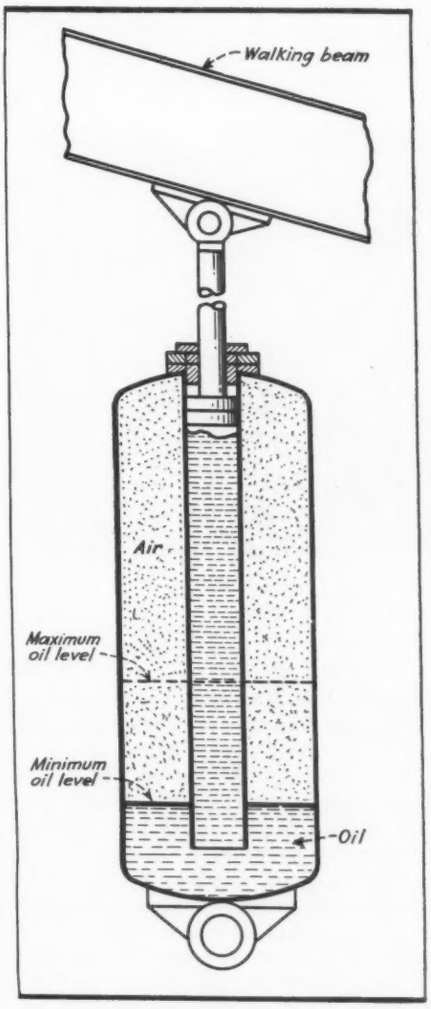
lubrication has been recently developed. The pump suction is through an external filter mounted on reservoir or on frame of the machine. Besides two terminal fittings on the reservoir cover for feeder loop line, there is a fitting for a copper tubing discharge line for flood lubrication. This design is particularly adaptable to modern machinery which is constructed to inclose as far as possible all gearing and shafts, and also in which it is necessary to supplement flood lubrication with controlled lubrication at some centralized points. Another distinct development is in the field of departmental lubrication. The unit is designed to automatically lubricate with fresh oil a large single machine or a department or battery of smaller machines. With this system a department can be equipped with centralized lubrication in the same manner as is commonly done for compressed air, water, gas, electric conduits for power and light, grinding coolant and other services essential for efficient manufacturing. The pumping unit is mounted on a 60-gal. tank and is driven by a ¼ hp. electric motor. If desired ring or chain-oiled sleeve bearings, ball or roller bearings can be supplied with a metered excess of oil. In such installations the oil level is maintained in the bearing reservoirs by overflow fittings to drain off the surplus. (69)

AIR PISTON to cushion shocks and to act as an inertialess counterbalance is being employed in an oil well pumping unit. In this pumping rig there are no heavy weights to accelerate and decelerate at the top and bottom of the strokes. By regulating either the pressure of the confined air, or the volume of the confined air, or both the pressure and the volume of the confined air the irregular forces in a cycle can be smoothed out as required. (*See illustration below.*)

AUTOMATIC LUBRICATION in which each bearing is served by a meter-unit no larger than a small-sized fitting has been developed to positively control the feed of the lubricant to the bearing. These units measure a predetermined volume of oil to the distributing system, whatever the size, speed or load as required by each individual bearing. These units can easily be designed into lubricating systems, the pump units and fittings are compact requiring little space. Small

Oil Well Pumping Unit Has Pneumatic Counterbalance

The Hydronumatic well pumping unit of the Parkersburg Rig and Reel Company has the pneumatic counterbalance attached to, and operating with, the walking beam at a point close to the polished rod. Thus loads supported and transmitted by the walking beam and other members are materially reduced, overall design is more compact and higher speeds with less vibration are possible. There are no heavy weights to accelerate or decelerate.



Inertialess counterbalance operates by compression and decompression of air in a hydraulically-sealed cylinder. Counterbalance effect can be varied by valve adjustment to meet individual conditions; amount is read on a gage.

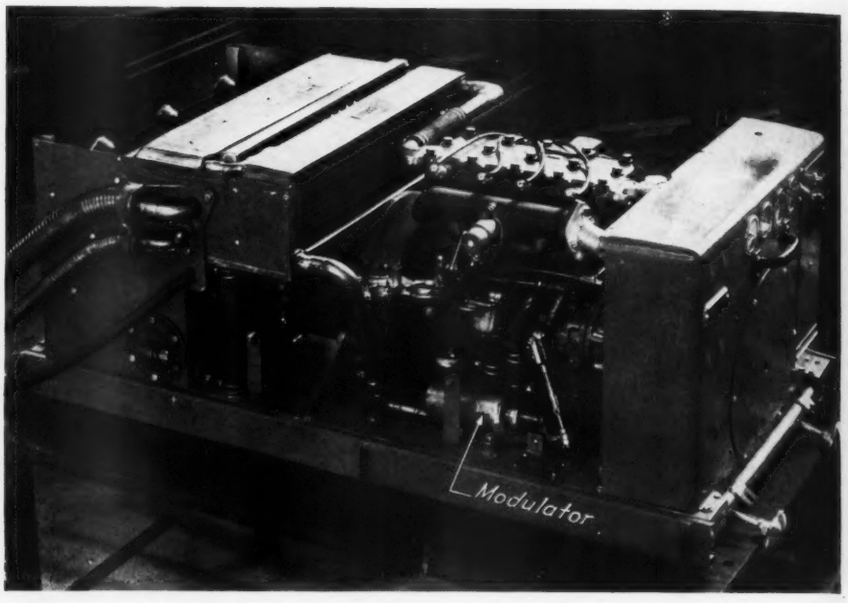
tubing of 5/32 in. O.D. is used which may be branched at any point to suit the machine construction. Where space is limited, branch tubes as small as 3/32 in. O. D. are used. Flexible tubing lines are readily provided to feed moving units or bearing mountings. Small bearings requiring a minimum quantity of oil are fed from the same system as are bearings demanding larger quantities. (70)

AUTOMATIC LUBRICATORS in small sizes are now made in variously modified forms and sizes to suit specific applications. These units have opened up a new and extensive field in centralized forced-feed lubrication. A new model with a reservoir capacity of one-quarter pint has recently been placed on the market. They are used on small machines where as little as ten drops per pump discharge is required, rather than the 30 or more drops of oil delivered in the older style lubricators. One lubricator unit may be set to give a delivery of from 2 to 30 drops per piston stroke. (71)

PACKAGED WEATHER UNIT (17 x 24 x 44½ in., weight 400 lb.) with a flexible capacity of 1½ to 4 tons, depending on demand, makes air conditioned passenger buses possible. The unit is mounted on six roller bearing wheels so that it can be easily pulled out for inspection or replacement. The connections are flexible enough to permit operation of the unit in pull-out position. The welded steel chassis is inclosed with aluminum alloy covers which permit the air to enter only through the filter at evapor-

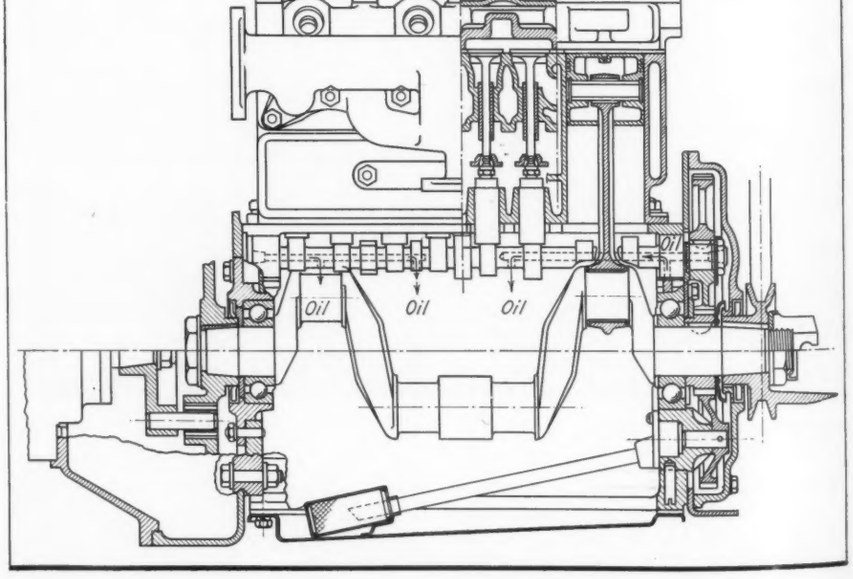
Waukesha Air Conditioner . . . . . .

PACKAGED weather unit, designed by Waukesha Motors for Tropic-Aire installations in Greyhound buses, weighs only 400 lb. and is compactly dimensioned to 17x24x44½ in. in size, yet has flexible capacity ranging from 1½ tons to 4 tons ice. The unit, mounted on six ball bearing wheels rolling in a channel-type tracks, can be withdrawn while operating for inspection or maintenance. Tracks are of welded steel.



Engine weight reduction to 128 lb. was accomplished by the use of an aluminum alloy crankcase, gear case, flywheel housing, pistons and cylinder heads. The drop forged, heat-treated crankshaft is mounted on ball bearings. Cylinder block is of molychrome steel. Connecting rods are drop-forged.

Engine lubrication is by pressure to the bronze bushings supporting the camshaft and by pressure-spray to the rods and gear train. The pistons, cylinders, valve tappets and main bearings are oiled by crankcase mist. A positive-drive centrifugal pump is used for cooling. Finned copper-tube coil condenser is partially submerged in water, while water is sprayed on the upper part from three nozzles with large non-clogging orifices. Water is circulated from tank to nozzles by a self-priming pump driven by V-belts from the engine. 900 cu.ft. of air per min. at 1800 r.p.m. is drawn through by the fan direct-connected to the front end of the engine crankshaft. To avoid vapor lock, the gasoline line is wrapped around the cool refrigerant line.



ator end. The filter at the unit and one in the bus panel are filled with bronze gauze. Steel tracks for the unit are mounted on cushion vibration dampers. *(See illustrated item below.)*

SMALL LUBRICATOR has been designed that will deposit just a spot of oil on the surface that needs lubrication. This oiler will deliver one-tenth of a drop of oil on the exact point where it will do the most good. The oiler looks like a fountain pen and can be carried around in the pocket without danger of spotting the clothing. Leakage is prevented by an oil-resisting neoprene gasket between the point and the barrel. Pressure on the steel point forces it up against spring pressure, opening a valve and forcing the oil to the surface. The amount of lubricant left in the oiler is always easily determined as the barrel is made from a transparent cellulose acetate plastic material. (72)

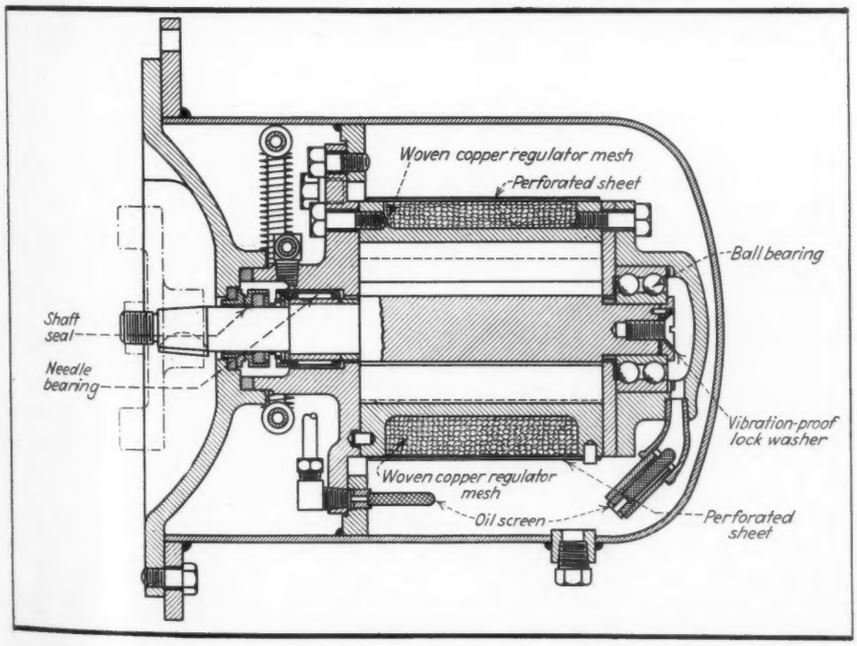
OILED AIR LUBRICATOR has been perfected for depositing oil at inaccessible points, surfaces and crevices for use on production lines as parts are assembled, where often a thin film of lubricant aids assembly. The oils used are liquid and are poured into the lubricator, but are deposited on the point or surface as a grease similar to vaseline. The equipment operates at from 50 to 60 lb. air pressure. (73)

SPECIAL OILS for precision service needed by one instrument manufacturer made

. . . . . *Designed for Bus Installation*

Evaporative condenser provides conditions comparable to 85 deg. dry bulb temperature irrespective of outside temperature. Water is supplied from auxiliary tank in the bus through flexible tubing to the condenser tank. Water level is maintained by a snap-action float valve with stainless steel seat.

FULL automatic control consists of a thermostat-governed electrical circuit operating in conjunction with a speed modulator. If the unit does not start after five cycles, a thermal switch disconnects the circuit until it is manually reset. This protects the unit against excess cranking when there is fuel shortage or other fault. Variations in speed and output are controlled by a modulation device connected to the governor.



Compressor is a rotary-ten-vane continuous-pressure unit with moving parts and vanes of nitrided stainless steel. Compressor vanes are hinged on the shaft and depend on centrifugal force for their position, giving instantaneous decrease in load when engine speed drops, and making starting at slow r.p.m. easy. Bearings are oiled by pressure of refrigerant. Finned pipe on cold side keeps oil cool; and a gauze filter separates oil from freon gas in the compressor. Seal at needle bearing end consists of two metal surfaces, held in contact by a spring. A synthetic rubber washer between the spring and metal seal makes the seal self-aligning. Compressor shaft is connected to flywheel through a cushioned coupling.

necessary an investigation of the many phases of lubrication problems connected with fine mechanisms. The studies made covered stabilizing treatments that were effective in minimizing oxidation, sludging, increase in acidity, or polymerization. Evaporation rate, rate of oil spreading, low and high temperature characteristics, and hydrolytic reactions were carefully studied. From data accumulated through tests new lubricants were developed for the lubrication of instruments, jewel bearing service, and fine machinery. (74)

BUSHING CONNECTION of the drive type, recently announced is designed to connect tubing to bearing holes where space is limited and there is insufficient room for threaded nuts or conventional bushings. The bushing is tapered and has a center hole which slides readily over the tubing which is later driven into a shallow tapered hole, the taper construction causes the bushing to fit tightly both the tubing and the walls of the tapered hole. Available in sizes for tubing as small as 3/32 in. O.D. for which size the drive bushing collar is only 3/16 in. outside diameter. (75)

PIVOTED TYPE BASES are normally associated with electric motor drives. However, one company uses a base of this type to mount a 55 hp. gasoline engine which weighs 1,815 lb. and delivers its power output at 1,800 r.p.m. to the driven machine. (76)

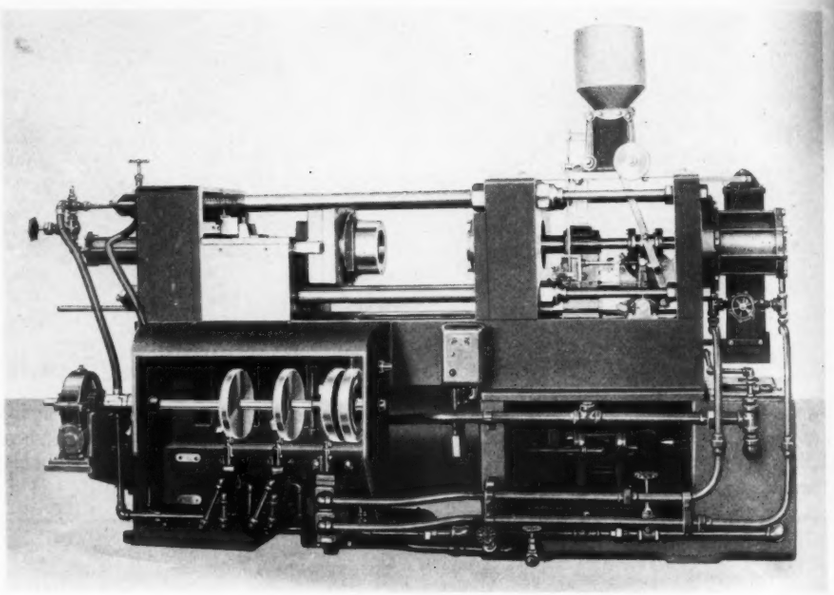
VIBRATION PROOF LOCK WASHERS which are pre-assembled to standard machine screws are the latest addition to the line of a manufacturer of metal fastenings. These assemblies are designed to speed up production by saving time formerly wasted in putting lock washers on screws. Each screw has the correct size and type of lock washer for its particular head. Waste and loss of lock washers are eliminated because the lock washer cannot come off the screw. (77)

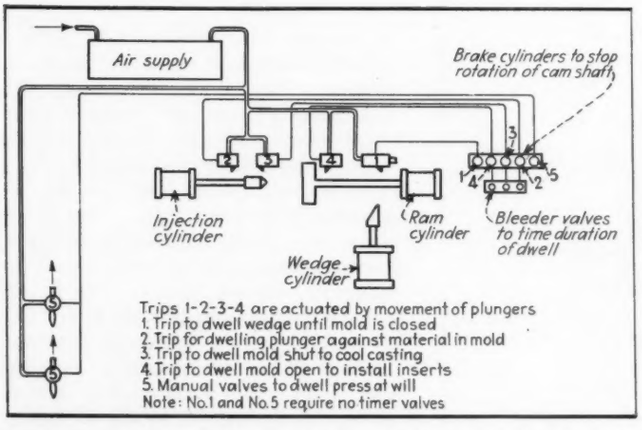
RECESSED HEAD SCREWS have been accepted by many manufacturers for assembly fastenings. The heads are recessed to receive a special screwdriver. Eighteen builders of automobiles and trucks are now using them in their cars. These screws are also being used on household electrical appliances, electric tools and furniture applications. Recessed head screws are obtainable in the form of wood screws, machine screws, stove bolts and sheet metal screws. (78)

Grotelite Injection Molding Machine

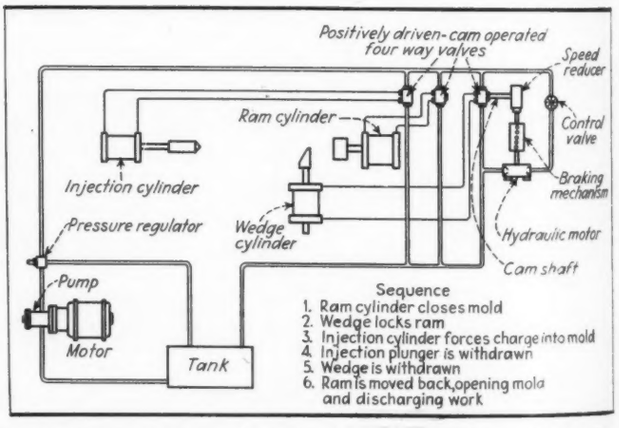
THREE CAMS, mounted on a shaft driven by a hydraulic motor, control the operation sequence in the Model 29 molding machine of the Grotelite Company. The only electrical control used on this machine is the starter button for the 10 hp. motor. This motor drives a hydraulic pump which develops a pressure of 10,000 lb. per sq.in. which is dispersed to three main control valves. Valves are operated by a hydraulic motor.

Cycle speeds can be varied from 30 to 500 cycles per hour. Control is flexible: manual, semi-automatic, or full-automatic operation being optional. Timing can be set up to 120 second cycles. Maximum injection pressure of 63,000 lb. is available; pressure on the material is adjustable to 30,000 lb. per sq.in. Injection plunger is of hardened, stainless steel. Oil reservoir is cast integral with the motor support and hydraulic pump is recessed in the machine base.




Air supply
Brake cylinders to stop rotation of cam shaft
Injection cylinder
Ram cylinder
Bleeder valves to time duration of dwell
Wedge cylinder
Trips 1-2-3-4 are actuated by movement of plungers
1. Trip to dwell wedge until mold is closed
2. Trip for dwelling plunger against material in mold
3. Trip to dwell mold shut to cool casting
4. Trip to dwell mold open to install inserts
5. Manual valves to dwell press at will
Note: No.1 and No.5 require no timer valves

Pneumatic circuit to time dwell periods is controlled by trip valves contacted by movement of injection and ram pistons. Air pressure is transmitted to an air brake stopping the hydraulic motor and cam rotation.



Hydraulic circuit which controls mold locking and injection on this machine. The locking of the mold, accomplished by a wedge, is positive to the extent of the shear strength of the steel. Wedge is of hardened steel.

ELECTRIC MOTORS AND DEVICES

ELECTRICAL EQUIPMENT continues to be constantly improved in regards to more compact units, better protection from over-heating, better and more durable controls, less noise and vibration in operation, and better contact materials. Special mountings and arrangements for built-in assemblies are more numerous. Integral mountings with gear reducers and mechanical variable speed transmissions are more common. Greater emphasis is being placed on automatic starting, stopping and timing devices in practically all industries.

VARIABLE SPEED A.C. MOTORS with fully continuous speed regulation without rheostat losses, that have shunt motor characteristics with speed practically independent of load, constant torque throughout the entire speed range and across the line starting are now obtainable in three-phase a.c., with a speed regulator unit which provides motor speed characteristics in general resembling those of a d.c. motor variable voltage control. The motor has a laminated stator core with a winding similar to that of a three-phase induction motor, the stator winding being connected to a three-phase power line. The laminated rotor core carries a single winding similar to a normal d.c. armature winding and is connected to a commutator in the usual manner. Instead of short-circuiting the motor brushes, a three-phase voltage opposite to the voltage generated in the motors by the revolving magnetic field of the stator is applied. The magnitude of this voltage is adjustable by means of a speed regulator which consists of two single phase induction type voltage regulators placed in one frame, the two rotors being mounted on a common shaft. These motors are suitable for operating at any speed from 1,800 down to 600 r.p.m., the lower speed limit being determined by the limited effectiveness of the cooling fan mounted on the motor shaft, when operating at speeds below 600 r.p.m. By using a separate motor driven blower for air cooling, the motor can be operated continuously at any speed down to practically stand-still. (101)

REVERSING MOTOR DRIVE of an improved heavy-duty type has been developed based on the principle that a slow moving mass because of less stored energy can be stopped in less time with the same effort than when moving at a higher rate of speed. Motor reversals have been speeded up by reducing armature speeds from the former standards of 250-1,000 r.p.m., and 200-1,000 r.p.m. to 150-600 r.p.m. and 100-600 r.p.m. in which the full horsepower capacity is maintained over the entire range. The improved drive, therefore, stops quicker. A part of the system is a new pendent control station with extra buttons for added convenience in setting-up operations. The rheostat panel for control of cutting and return speeds is made in a separate unit which can be mounted within easy reach. (102)

EXPLOSION-PROOF D.C. MOTORS in a wide range of both electrical and mechanical modifications are now offered by an electrical motor manufacturer in a.c. and d.c. NEMA frame sizes. These motors are especially built for gaseous mines and are particularly adaptable for use in low overhead spaces. The cooling

fan is of the radial type and cast from a special non-sparking alloy high tensile aluminum to prevent breakage, it is keyed and locked to the commutator end of the motor shaft. (103)

GEAR SHIFT ON ELECTRIC MOTOR. An electric motor with a gear shift built in has been recently announced. The gear shift is the same as that used in automobiles to obtain three forward speeds and one reverse speed. This gear shift when attached on a two speed motor makes it possible to drive the connected machine at any one of six forward speeds. (104)

SPECIAL ELECTRICAL APPARATUS, concurrent with progress in the design and operation of aircraft, has been developed that is light in weight, such as gasoline engine driven generating sets for power supply; d.c. motors for landing gear, for wing flaps and for hoists; and specially designed motor generators for radio and signalling devices. (105)

MOTOR ROTOR that is said to eliminate end thrust and back and forth lateral pounding has recently been patented and developed. The feature of the rotor is that the bars are shaped like herringbones. It is claimed that this construction of the rotor improves the electrical characteristics by reducing circulating currents, exciting currents, heating, eddy currents and iron losses, and also by increasing the pull-out torque, starting-torque, efficiency and power factor. (106)

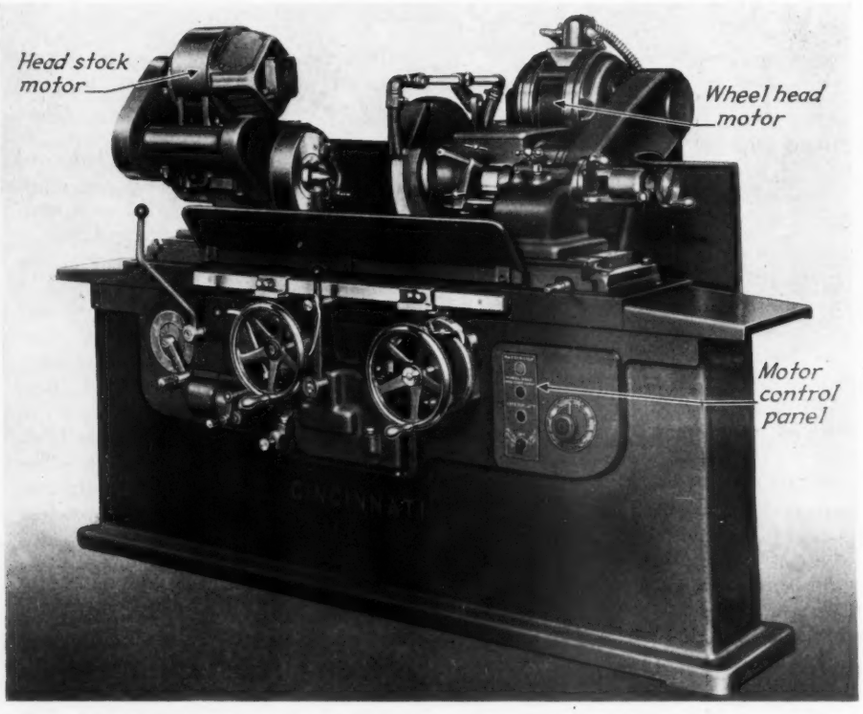
SMALL GEARED MOTORS are being made by an increasing number of manufacturers. One manufacturer has amplified his line of geared motors to include a selection of speed ratios up to 3,600 to 1 giving torque up to 400 lb. in. on the drive shaft. (107)

RESILIENT MOUNTINGS for motors particularly in the larger sizes have been increasing in use. Small motors down to about 3-in. frame sizes are now obtainable with resilient mountings. (108)

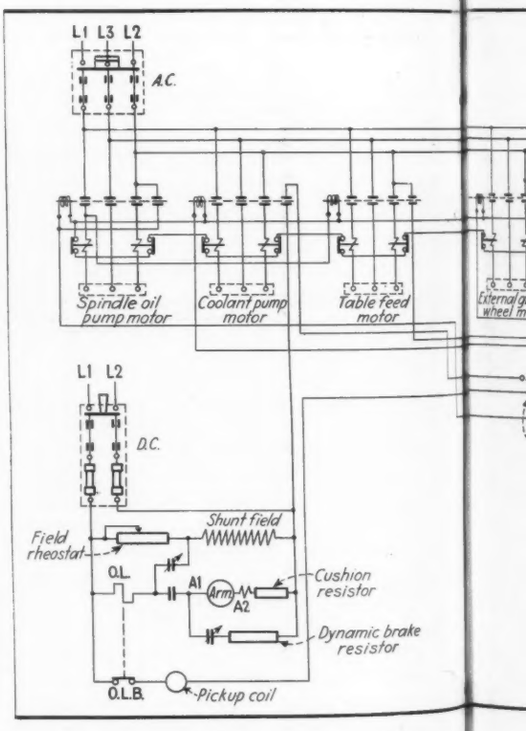
MOTOR SLOT INSULATION material of improved quality and of high dielectric strength has been developed within the past year that is designed to protect coil windings and to prevent ground failures. The material is said to be flexible, tough, non-corrosive, and extremely resistant to edge tearing. It has an all-rag content which provides a high density insulating paper. The material will stretch as much as 10 per cent before tearing and bends easily without fracturing in either grain direction. The minimum dielectric strength is 300 volts per mil thickness. It has a minimum tensile strength of 15,000 lb. per sq. in. with the grain, and 7,000 per sq. in. across the grain. This material is furnished in sheets approximately 42 in. x 40 in. and in thickness ranging from 0.007 in. to 1/32 in., thicker materials can be made. (109)

BUILT-IN FEATURES continue to be the trend when designing for appearance and increased operating efficiency. So long as design considerations for appearance do not detract from operating convenience, capacity and efficiency, features of this kind are considered worthwhile, since usually they constitute very useful and desirable qualities. Control panels with controls for multiple motors and rheostats placed near the operator are still in favor. Sheet iron boxes that contain electrical control elements are now usually recessed in the bed to minimize the height of projection. Electrical control buttons in late designs are flush with the front of the machine,

Built-In Electrical Controls . . . . . .



Built-in switches, rheostats and electrical controls are a feature of the new Cincinnati Universal grinder. Control buttons are built into compact units, set into and flush with the front of the bed casting; the electrical starting and control equipment is grouped under a hinged cover on the right-hand end of the machine. Power is transmitted to the table through a multiple-disk clutch, which protects the gearing and transmission bearings since it will slip under shock load; it also absorbs table-reversal shock. 1 hp. table drive motor is used.



Electrical control circuit. The standard machine has five motors, all of which are controlled from the panel in front of the machine. A hand control lever in front of the table stops work rotation, coolant and table traverse at the same time. The headstock spindle

and rheostat knobs, extend from the machine merely for convenience in grasping to change the work speed. (110)

EXPLOSION PROOF INCLOSURES which will meet the requirements of class 1, group D hazardous locations, for inclosing rheostats are now obtainable for installation in oil refineries, filling stations and distilleries where explosive gases are present, such as from gasoline and alcohol. These inclosures are cast iron and have a pad tapped for ½ in. pipe connection for the entrance of wires at the bottom of the case. These cases accommodate 8 in., 13 in. and 15½ in. diameter rheostats. They are regularly furnished for front of board mounting, but can be arranged for use with manual drive accessories. (111)

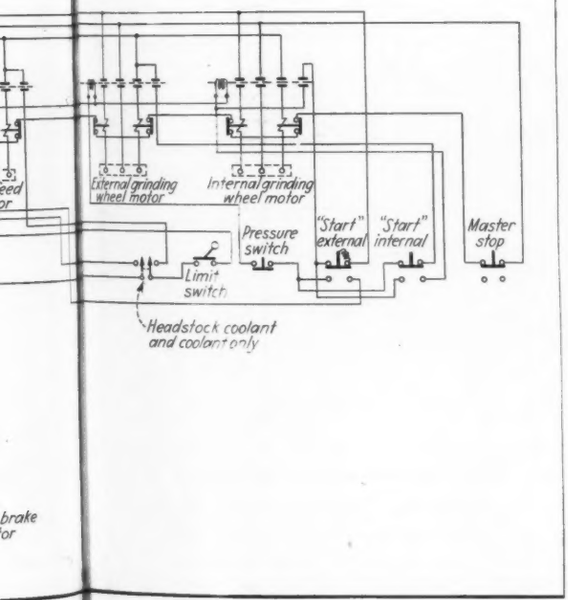
ELECTRIC SWITCH of new design reverses the conventional procedure and puts the arc-extinguished structure on the moving contact blade instead of on the stationary contact. The arc-extinguishing chamber moves in and out on the stationary contacts as guides. The piston-action of the contact when rupturing in the arc chamber tends to evacuate a small amount of air present in the restricted inclosure, thus minimizing ruining the arc chamber or the contacts by reducing the oxygen available to support combustion. What little arcing there is, is confined entirely within the arc chamber, preventing the arc from getting out to the other switch parts. (112)

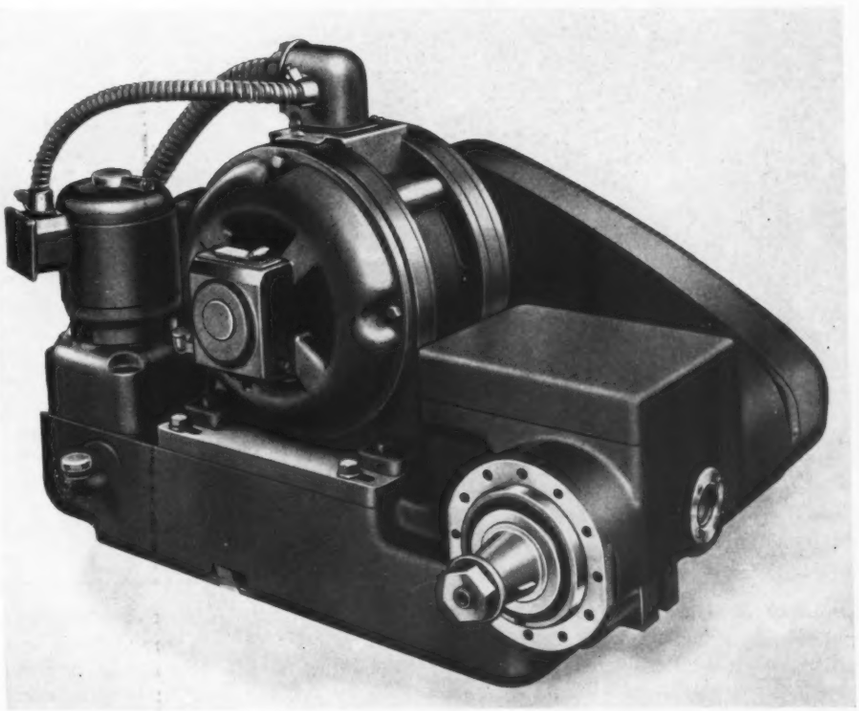
ELECTRONIC TIME DELAY of the repeating type has been designed to flash a light at the rate of 40 flashes per min., the light being on 1 sec. and off ½ sec. for applications such as flashing of lights on a continuous cycle. The delay for the off period is provided by the time required for the filament of a vacuum tube to reach sufficient temperature to emit enough electrons to energize the control relay. The delay for the on time is provided by a condenser connected across the coil of the control relay and the time required for the filament of the vacuum tube to cool. Other timing combinations may be obtained by the use of vacuum tubes having different filament characteristics and various sizes of condensers. (113)

TIME DELAY RELAY of the air dash-pot type has been placed upon the market in which the armature opens and closes immediately. For delay on pick-up the dash pot is operated by a spring which is tensed by pick-up of the armature and the contacts operate after the time delay for which the dash pot is adjusted. The contacts reverse instantaneously when the armature of the relay opens. For delay on drop-out the reverse operation occurs, the dash pot being picked up immediately and dropping out under the pull of the spring tensed by the drop-out of the armature. Timing is adjustable up to 30 sec. on pick-up or drop-out. (114)

RECYCLING TIME DELAY relay, motor operated, has been completely redesigned which now uses a greatly improved type of clutch and cam operated contacts and an improved method for adjusting the timing. The unit can be furnished with gearing to suit practically any time interval. The timing accuracy of this unit is obtained by the use of a synchronous motor together with ease of adjustment, the immediately recycling feature permits its use in practically any timing application. Auxiliary relays may be used if more than one circuit must be controlled or if the load is in excess of the timing relays rating. (115)

Increase Operating Convenience





may be started and stopped independently by means of pushbutton control. Stopping of work rotation is instantaneous, through the medium of a dynamic brake built into the workhead motor. Work speeds may be varied from 60 to 240 r.p.m. through rheostat adjustment.

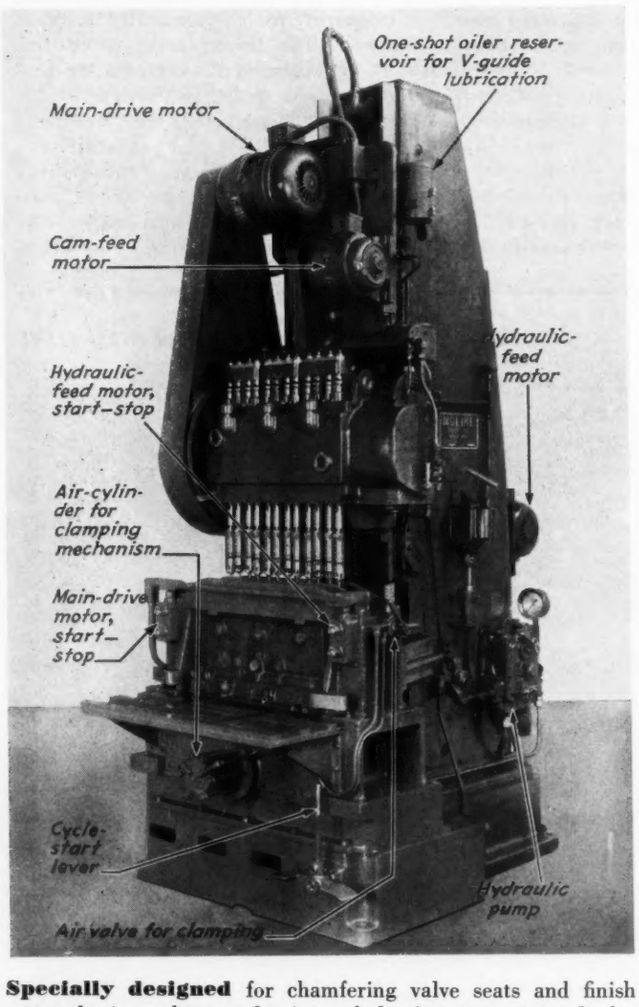
Wheelhead unit provides for adjustment of the wheel to the work through square gibbed slides and narrow guides protected from water and grit. Bearings are of the multiple shoe type; the bearing area on the spindle is lapped to a smooth finish. Oil is pumped through a renewable filter; oil pressure must reach four lb. to actuate the pressure switch which starts the main drive motor. If oil pressure drops, the motor will be stopped. When the filter becomes clogged, oil is by-passed back to the built-in reservoir, stopping the motor.

HYDRAULIC FEED is a feature of a recently developed drilling machine. The machine is also equipped with air operated fixtures, also an air cylinder which operates a toggle and wedge lock mechanism to clamp a block securely against a stationary plate. When in operation the hydraulic pump feeds a moving carriage to a predetermined positive stop. At this point hydraulic pressure holds the carriage stationary against the stop and a small motor automatically starts to rotate three cams which do the actual feeding of the tools into the work. The cams are set in such a way that all three groups of tools do not start to cut simultaneously, but are fed in and brought back with a slight time lag between similar portions of the cutting operation. When the cams have finished their movement and the tools have been withdrawn, the small motor is stopped automatically and the carriage returns hydraulically to its starting position. (*See illustrations on this page.*)

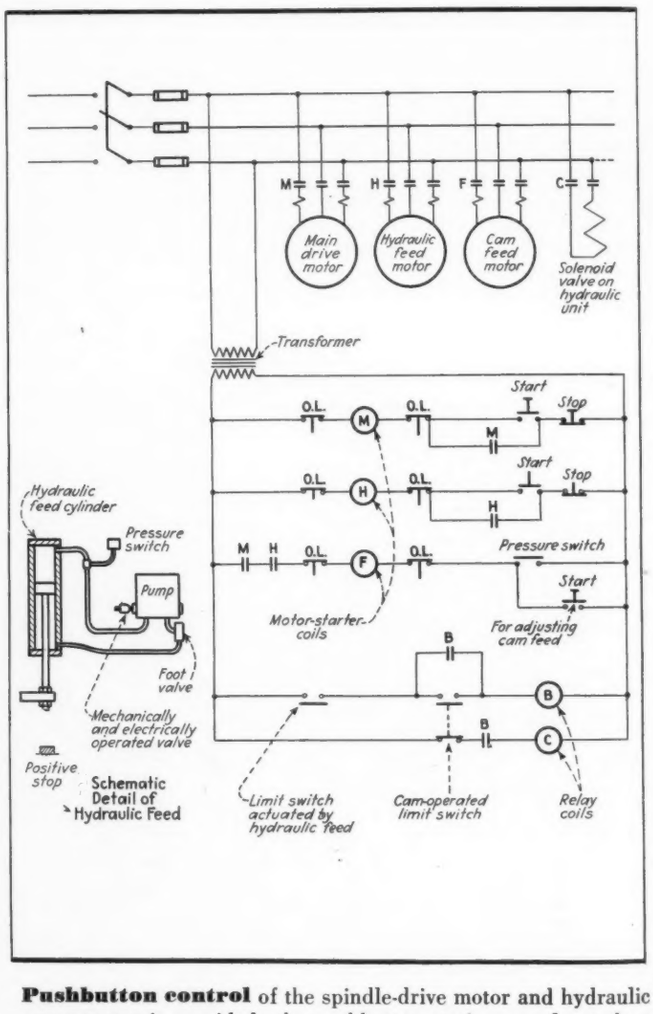
SENSITIVE A.C. RELAY with single pole, double throw contacts has been placed on the market that makes use of nickel alloy in the magnetic circuit so as to assure good sensitivity, good contact torque at pull-up and a constant drop-out. Coils are available for currents from 1.5 to 450 milliamperes. Large knurled nuts are provided for making adjustment of the silver contacts and armature spring tension. This relay is furnished with a plastic molded base that is approximately 2 in. square which can be mounted in any position without affecting the performance. (116)

MIDGET RELAYS for heavy duty are now available with single pole, double break, and normally open contacts, that are provided with extra large fine silver to silver contacts to provide maximum contact rating of 10 amp. up to 125 volts

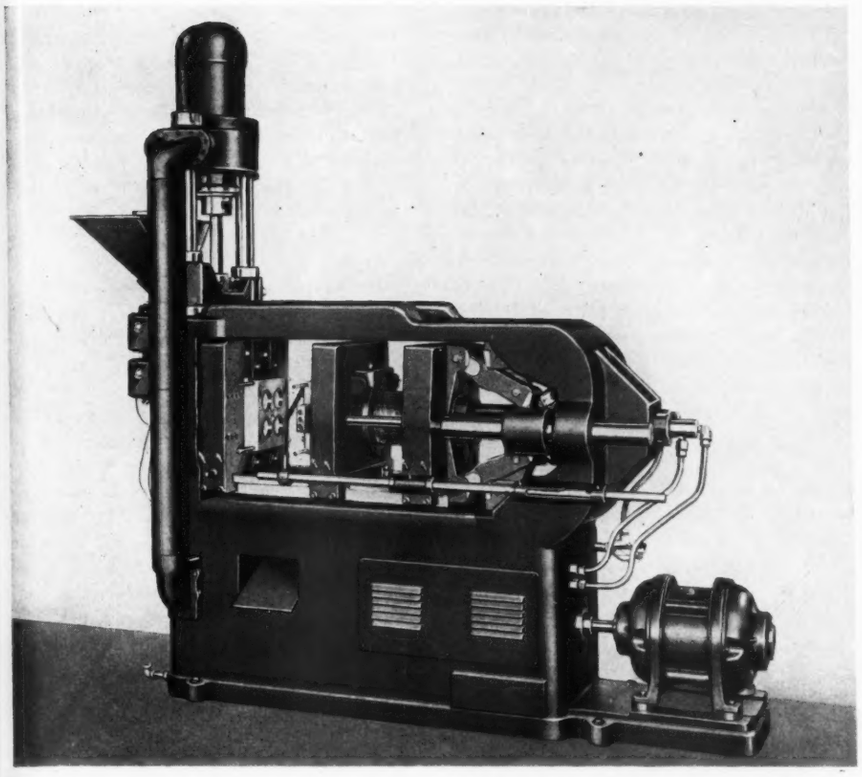
Interlocked Hydraulic-Electric Control



Specially designed for chamfering valve seats and finish counterboring exhaust valve insert holes in automotive cylinder blocks, this drilling machine, developed by the Moline Tool Company, is equipped with an air-operated holding fixture. An air cylinder which operates a toggle and wedge lock mechanism clamps the block securely against the stationary top plate of the fixture. The twelve spindles, rotated by the standard Moline spiral drive, are arranged in three groups of four each, with each group being actuated by one cam. The cams are so designed that each group of spindles is fed down at an initial rate of 0.013 in. per revolution, followed by 0.003, 0.008 and 0.004 and ending with a dwell.



Pushbutton control of the spindle-drive motor and hydraulic pump motor is provided; the pushbutton stations are located on the fixture for easy accessibility. The hydraulic pump feeds the entire moving carriage down to a predetermined positive stop; at this point hydraulic pressure holds the carriage stationary against the stop and the small motor starts automatically to rotate the work-feeding cams. When the cams have finished their movement and the tools have been withdrawn, the small motor is stopped automatically and the carriage, which moves on heavy double-V guides, is returned hydraulically to the starting position. Estimated production on this machine is 75 to 80 cylinder blocks per hour.



Index Machinery Company's LPM injection molding machine is available in 4, 6, and 8 oz. capacities. Three timing switches and two temperature controls govern automatic operation. The master control assembly, consisting of timers, relays and contactor is recessed in the machine base.

A polyphase motor of 10, 15 or 20 hp., depending on the capacity of the machine, drives the hydraulic pump. Design features of this machine, including the electrical control circuit, will be more fully described and illustrated in the December number of Product Engineering

a.c., 10 amp. up to 22 volts d.c., or 2 amp. from 23 to 125 volts d.c. These relays are mounted on a molded insulated base. (117)

DIRECTIONAL RELAY has recently been designed with two torque-producing elements on one shaft. One element is a polyphase power directional element and the other is a voltage restraint element, forming a directional relay which normally stays in the open position. When a fault occurs, the voltage restraint collapses, allowing the directional element full control. In addition to its use as a crude polyphase impedance relay, it gives satisfactory directional control and can be used with instantaneous as well as delay overcurrent relays because it cannot close its tripping contacts on low current. Only the control voltage is on the contact so there is no chance of not making contact because of low voltage or any other difficulty in short circuiting overcurrent relay coils of low impedance. (118)

IMPROVED PATENTED ALLOYS have been developed for applications requiring high currents, where pitting or welding of contacts is likely to occur. Other applications where this material may be used include arcing tips on air circuit breakers, heavy duty circuit breakers and relays and applications where frequency and pressure is high. The alloy is copper and tungsten or molybdenum and copper, a combination which produces high electrical conductivity and hard wear resistance qualities. Applications are for spot welding steel, for projection welding, flash welding, and electrical brazing. Another alloy of silver and tungsten or molybdenum produces a much higher conductivity. Its principal use is a facing material for high current density contacts. (119)

LAMINATED CONTACTS are now available with a silver contact face and a steel back, which provides for steel-on-steel welding. These contacts are especially designed for projection welding and afford a permanent bond between the silver and steel. These contacts are available in diameters ranging from ⅛-in. to ½-in., with heads from 3/64 in. to ⅛ in. thick. (120)

COMPOSITE SILVER RIVETS have been announced that consist of a silver contact face bonded to an under head and shank made of base metal. The nature of the bond is such that it has high strength and good conductivity. The silver facing is solid since it is made from rolled silver which is free of contamination, blow holes or other imperfections. The backing material is usually copper, bronze, nickel or steel, although other workable base metals may be obtained. Where corrosion resistance is required, nickel backing is recommended. When the contact rivet is used to fasten several members together and high tensile strength in the shank is required, the steel backing is recommended. When steel backing is used the rivet may be furnished silver-plated. (121)

MANDREL WIRES are available in either steel, brass, or molybdenum for use in coil winding. These can be supplied in tolerances as close as plus or minus one per cent by weight. While this wire is primarily made for use in the winding of tungsten filaments for lamps, it will also serve where wire of extremely clean and bright surface and exact diameter is needed. (122)

SURFACE WIRING SYSTEMS with mounting blocks and covers made of porcelain are offered in a new line. These devices require no boxes or connectors, neither is splicing, soldering or taping necessary. The devices are complete with cable clamps for fastening armored or non-metallic conductor cable. The exterior of the porcelain parts is finished with a baked enamel finish. Jewels made from a transparent red plastic material are used for pilot light windows. (123)

ELECTRIC ALARM and communication system that can be installed by simply plugging the transmitting unit in the nearest electric outlet and then plugging in the receiving unit or broadcasting unit at another convenient electric outlet has recently been announced. (124)

NEW TRANSFORMER designed to operate two 400-watt mercury lamps at peak efficiency and at a 90-95 per cent power factor has recently been offered by a manufacturer of a line of transformers for mercury lamps. Starting currents when using these transformers are below the normal operating current, so that no provision need be made in the wiring to take care of excess starting values. The wiring in branch circuits can be used at full capacity. With the new unit one lamp starts and reaches its full efficiency before the other lamp. With as much as a 40-volt drop in the circuit, one lamp will continue to burn. Should one lamp burn out, the other lamp will operate normally without injury to the transformer. (125)

FLUORESCENT LIGHTING has been made practical through the design of an electrical discharge device which makes use of the ultra-violet energy from a mer-

cury vapor arc to activate a fluorescent material coating on the inside of tube surfaces. This fluorescent powder may be one of several synthetically produced inorganic chemicals known as phosphors. In its present form, the lamp consists of a tubular bulb with two auxiliary contacts at each end which are connected to filament type electrodes of coiled tungsten wire. Within the bulb is also a small drop of mercury under a few millimeters pressure of argon gas, the latter to facilitate starting. The color of light from fluorescent lamps depends principally on the chemical nature of the powder but physical form is also important for efficiency and ease of application. Five colored and two white lamps are now commercially available. Three of the colored lamps blue, green and pink and the two whites appear white when unlighted; the other two colors, gold and red, appear in their natural color since they have additional coloring pigment in order to enhance the desired shades with the phosphors now available. The power factor of the lamp itself is approximately 90 per cent, the difference between 90 per cent and 100 per cent being due to wave distortion. With the necessary auxiliary, the power factor is 50 to 60 per cent. (127)

FLUORESCENT TUBING has greatly advanced the field of electrical display signs and interior lighting effects. A variety of colors and color combinations having great brilliance is now available in this new tubing. Some of the advantages attained are great brilliance with small amount of current and wide range of colors and color combinations. The color fills the whole inside diameter of the tube, since no core is visible, color is uniform, tubes are cooler, the light is steady without flickering or sputtering, the fluorescent powder is bonded to glass and does not flake off, the tubing bends as easily as ordinary clear glass, holds its color in cold weather and the tubing can be reprocessed. (128)

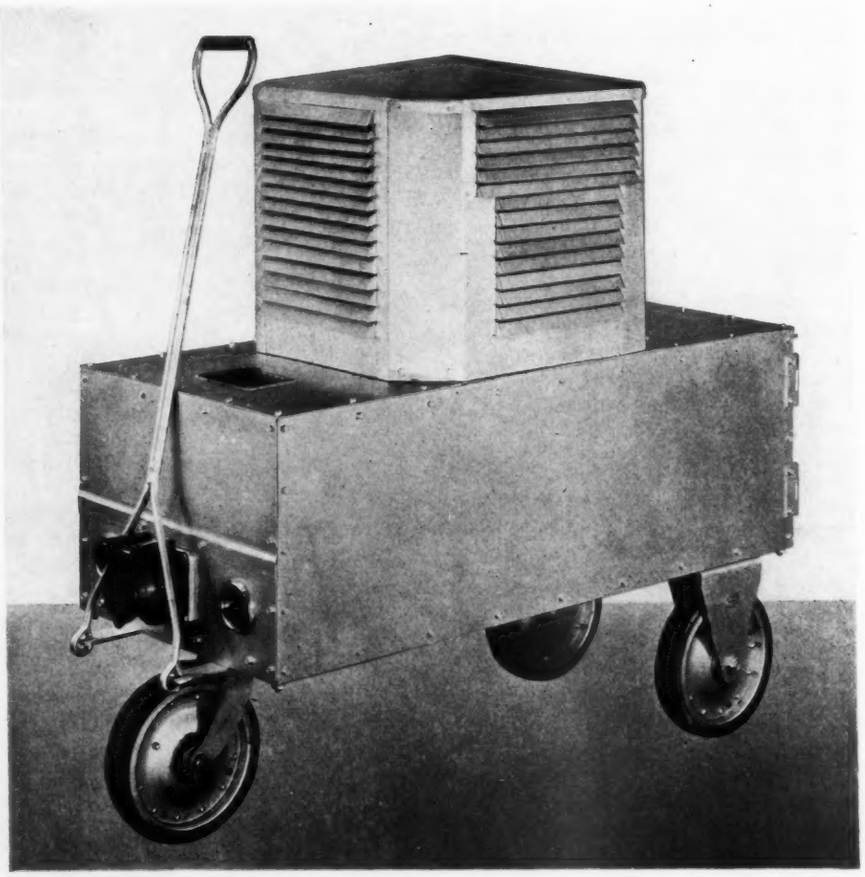
CANOPIES for fluorescent lamps have kept pace with the rapid strides recently made in the development of fluorescent lamps. One company has developed five different models of canopies for utilizing these new lamps. Each of the models uses the same canopy and the same type lamp assembly. Each is equipped with all necessary wiring, sockets and auxiliary switches, ready for installation of two 18-in., 15-watt fluorescent lamps. The models are designed for overhead installation, bench or table installation. (129)

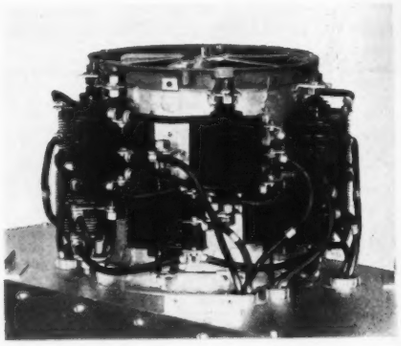
REFLECTORS are now being made of a urea plastic material with a threaded ferrule at the base which permits it to be screwed directly onto an electric light bulb. A new 12-in. reflector molded of the same material is also being made which can be screwed into any overhead socket in which the reflector bowl itself is suspended by a chain upon a center ring which fits over the light bulb. (130)

DESK LAMP which is made entirely of molded plastic material, even the lamp shade and the light socket, has an interesting feature in that the finish that has been given to the interior of the lamp shade is a surface coat of aluminum paint which is said to make an excellent reflecting surface. (131)

BATTERY CHARGERS of the heavy duty type have been simplified in construction because recently developed propeller-type blower fans are able to work against considerable back pressure. Air is forced under pressure through a drum in which the rectifiers are radially mounted. The frame is of arc welded design from commercial structural forms and so made as to gain maximum strength with minimum weight. *(See illustrated item below.)*

Mobile Battery Charger





Construction was simplified in the P. R. Mallory & Company heavy-duty mobile battery charger by utilizing a power dome. Magnesium-copper sulphide rectifiers are mounted in a drum, into which air is forced under pressure by a recently developed propeller-type blower fan designed to work against considerable back pressure. Fan motor is a small, single-phase fractional-horsepower motor such as is used in household appliances.

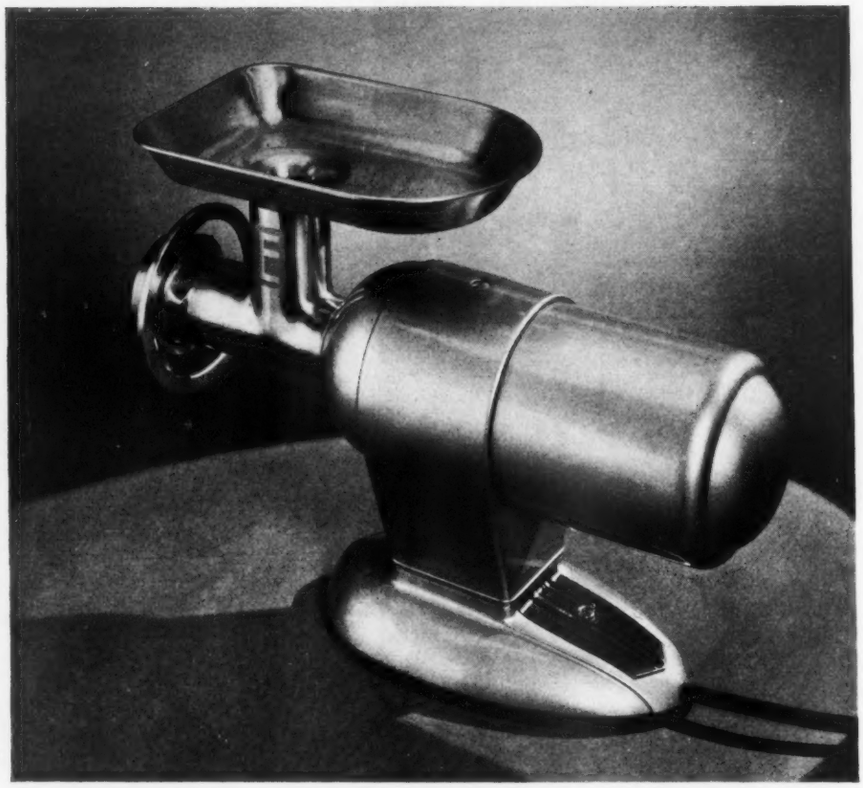
Changes in rectifier output are accomplished by moving the wander plug from one receptacle to another. A Y-connected transformer is used in the circuit and no cord to the wander plug is required. The transformer is located in the housing immediately below the power dome. Frame is of welded construction.

FINISHES AND PROTECTIONS

INDUSTRIAL FINISHES. A new product which is the result of a distinctive formulation, and having an action based on the principle of polymerization, a chemical reaction whereby molecules combine under suitable conditions to form molecules of more complex and stable structure. It does not dry by oxidation. Oven temperatures and the mass of metal determine the processing time which varies between a few minutes and a few seconds. Only one bake is required. This finish is suitable for washing machines, office equipment, metal furniture, toys, stoves, hospital equipment, plant machinery, electrical appliances, and other types of metal products. It sprays freely, or it may be dipped. Tests show that the finish is resistant to all common deteriorants. Flexibility and adhesion are reported to be equal to those of any synthetic resin finish. The finish comes in any color and in any degree of gloss or dullness. It is also available in a clean white permanent to sunlight, and is also adapted to products which are subjected to alkalies, acids and other discoloring agents. In some applications this finish adheres to bare metal without undercoating. It "sets-up" so rapidly that a dust-free surface materializes quickly. It will not collect dust or foreign particles floating in the air either before or during polymerization. (132)

WRINKLE FINISH PATENTS. For the purpose of bringing about a greater appreciation of wrinkle finishes in all of their phases, to broaden their scope as a logical and colorful application to a thousand and one products beyond their present use, to provide each source of supply operating under license with the necessary incentive to preserve quality and render the service necessary with a customer to assure uniform results, all available patents on wrinkle finishes have been brought together under one central head and through the establishing of licensees at all strategic points throughout the country to permit immediate expert advice on wrinkle finish application and prompt delivery. It is placing at the disposal of product finishers a nation-wide organization well equipped to help them solve wrinkle finishing problems. Organized to control the patents on wrinkle finishes used on radios, cash registers, typewriters, and a line of similar products, this concern has acquired 17 American and two Canadian patents. These patents cover all the irregular surface finishes generally described as wrinkle, crinkle, shrivel, morocco, which are produced with China wood oil, and applied to both oxidized and non-oxidized finishes. (133)

WRINKLE FINISH of uniform texture in

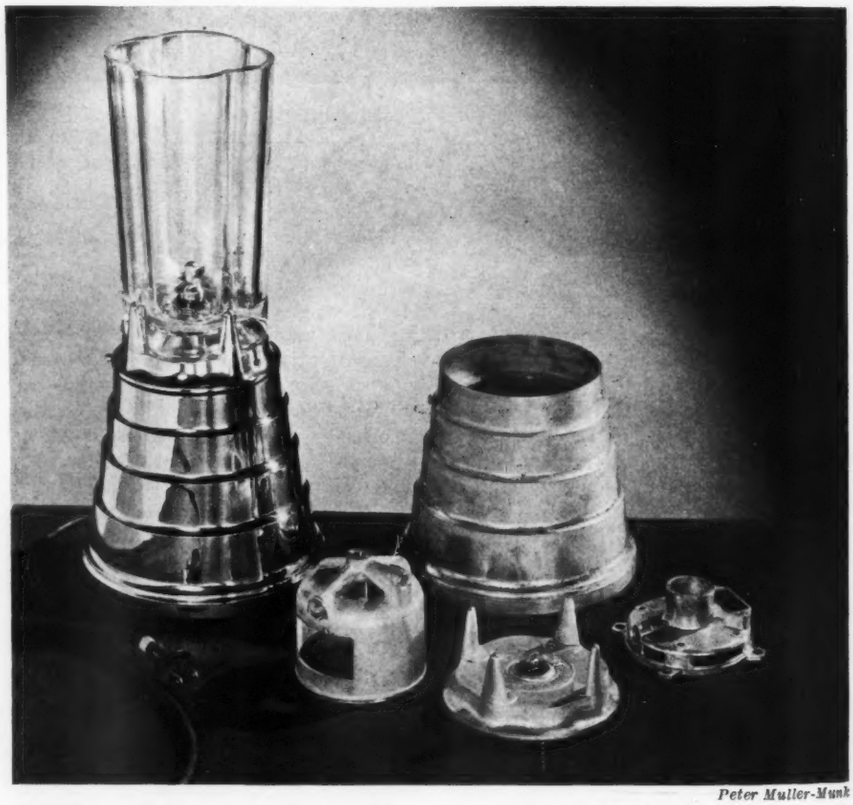


Enterprise meat chopper has a polished cast-aluminum motor housing, stainless steel plates, and meat tray of satin-finished chromium on steel. Chopper is driven by a 3/4 hp. repulsion-induction motor of the "brush-lifting" type. Gears run in oil

attractive shades can now be obtained. Designed especially for metals, the wrinkles are flat and extremely close together. One coat of this new finish gives complete coverage of the metal. It completely eliminates the appearance of slight imperfections found on the surfaces of the less expensive grades of metal. The finish has unusual adhesion properties and protects the product against scratching or chipping. No undercoat is necessary. The material is ready for spray without reduction when received. The sprayed product reaches full hardness within 48 hours after it has been baked for about one hour at 250 deg. F. With higher baking temperatures the baking period is considerably reduced, but high temperatures will bring about considerable change in color. It will bake in any type of oven and may be left out of the oven up to four hours and still produce a satisfactory wrinkle. Both vertical and horizontal surfaces may be sprayed on the same piece with good results. (134)

THERMOPLASTIC RESINS that are water-clear are now finding commercial application as impregnants for wood, cloth, paper, electrical apparatus, metals and stone. Materials when treated with these new resins are more resistant to water, oils and chemicals. It is said that when wood is impregnated with this resin that the wood is stronger and more resistant to water absorption, warpage and the action of chemicals. These resins possess excellent film-forming and adhesive properties, and because of their wide compatibility with solvents, plasticizers and resinous materials they readily enter into more complex formulations. Emulsified compositions can be prepared readily for coating by spraying, brushing or dipping at normal temperatures. Films flowed from emulsions are characterized by the same toughness as films deposited from melt. (135)

CHLORINATED RUBBER is the base of a new finish. It is stated that the films set rapidly and are dry enough to tape in six hours. These enamels air dry or bake (1 hr. at 180 deg. F., for 30 min. at 250 deg. F. are typical schedules). The lasting adhesion and flexibility not only permits fabrication of parts after finishing, but also provides a protective and decorative finish which withstands rough handling at assembly and hard usage in service. This chlorinated rubber finish is made in two general types of coatings; they are a highly efficient corrosion-resistant coating, and a low baking fast air drying decorative finish. Coatings for specialized applications are also available. This material is now being used by a manufacturer of air conditioning equipment, because of its



Peter Muller-Munk

Chromium-plated zinc die-castings form the base and motor housing of the Waring electric mixer. Agitator, made of stainless steel, is driven by a two speed universal motor. Special shape of glass mixing bowl and design of the agitator blades produces a whirlpool of effect and prevents splashing; thus no cover is required

high corrosion resistance. This material can be made to yield high gloss, full bodied enamels in white, black and colors, which eliminate the need for high temperature bake ovens. Enamels made with this material bake hard in one hour in steam ovens which maintain temperatures of 180 to 200 deg. F. When an oven temperature of 250 deg. F. is available, this finish bakes hard in 30 min. The quick initial dry enables men to work on and around specially painted products without fear of damaging the finish. After drying six hours it does not mark under masking tape. A two color combination may thus be applied on the same day, and the product will be ready to ship the next morning. For general industrial use, one coat directly on properly cleaned metal produces a finish with tenacious adhesion, mar resistance and the flexibility necessary to prevent chipping even under severe impact. It resists gasoline, oil, food acids and vegetable oils, as well as the best synthetics, and furthermore, the chlorinated rubber content fortifies it in its resistance to soap, perspiration, salt spray, humidity and other factors in finish failures. These coatings may be applied to unsized flat tin or aluminum sheets by roller coating machines, baked to a tack-free finish, and then blanked, drawn and sometimes knurled to make metal caps for bottles and other packages. The appearance is smooth, bright and glossy. It can be used as an undercoat for wood cabinets, kitchen furniture, and masonite board in which applications it air drys so quickly that they can be wet sanded and recoated in either lacquer or synthetic enamel in about two hours time. (136)

BLACK ENAMEL of a new type with special dielectric properties especially suited for finishing electrical apparatus, such as steel switchboards, instrument panels and coils, dries to a rubber finish and is tough, durable and has high electrical resistance. It is applied by spraying. A surfacer, with similar dielectric properties, is also supplied for preparing the surface to be finished. (137)

SYNTHETIC ENAMEL that looks like porcelain and requires only a short-bake is said to cover excellently in one coat, laying on with a full smooth film. It can be applied by brush, spray, dip or tumble. Along with hardness and marproofness it is claimed to have chemical resistance, especially to solvents. (138)

TITANIUM DIOXIDE PIGMENT for baked lacquers which will withstand high temperatures without yellowing has been developed. The pigment has sufficient color stability so that supplementary pigments are not required. It is claimed that its color retention is superior to that of the regular grades of titanium oxide in both air-dried and baked coatings. Also that it develops less discoloration in plastics. It is available in two grades, one of medium oil absorption and the other of low oil absorption. (139)

BRASS MARKING INK has been announced which can be applied by pen or rubber stamp. It dries very rapidly and in a few seconds it turns black, contrasting with the brass background. This ink has a general application where brass, copper, silver or bronzes are to be marked. (140)

GLASS MARKING INK is available which when burned in leaves a silvery deposit on the glass. It may be used for identification or for special decorative purposes. (141)

ABRASION RESISTANCE TESTS that were primarily developed for use with vitreous enamels may also be found useful on other materials having moderately soft and glossy surfaces, such as glazed ceramic ware, glass, plastics, painted and lacquered parts. In this new test, powdered abrasive and small spherical weights are placed on the face of a flat specimen confined within a walled-in area. The entire assembly is then agitated in a horizontal plane by means of a commercial "screen shaker." Water is usually added to avoid the effect of variations in atmospheric humidity. Wear resistance of the specimen is measured by the change in the specular gloss of the surface as determined by photoelectric means before and after the test. The percentage of the original specular gloss retained after the test is taken as the abrasion index. Abrasion index values obtained by this method have ranged from about 70 for a hard, acid resisting sheet iron enamel to less than 20 for a soft lead wet-process enamel for cast iron.

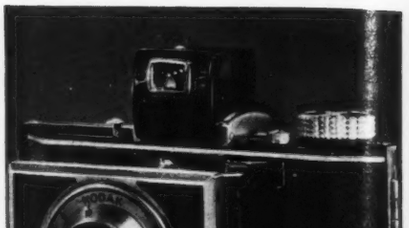
In conducting the tests it was found that feldspar was excellent as the abrasive agent for vitreous enamels. But in testing much harder or much softer materials the abrasive should probably be correspondingly harder or softer. For comparing different types of materials

Polymerized finish is used on the steel base and legs of the new deluxe Easy washer. Other features include porcelain enameled tub, polished aluminum tub cover, die-cast polished aluminum top ring, die-cast zinc control handles and zinc tub bands, chromium finished, and an aluminum dryer basket and spiralator, with rust-resistant finish. The ¼ hp. General Electric motor that drives the machine has automatic timing control. Other features are similar to the Easy washer described in May 1938 Product Engineering, Modern Designs section

with each other, the determination of the duration of the treatment or the number of strokes the sample must be shaken to produce a given effect is preferred, rather than basing the index on the loss of specular gloss in a given period of time or number of vibrations. (142)

COATING-THICKNESS GAGE for measuring the thickness of non-magnetic coatings on iron or steel is constructed with a spool-like steel head, the two flanges of which both make contact and assure accurate measurement on curved as well as on plane surfaces. The gage can be used for determining thicknesses of porcelain enamel, paints, lacquers, varnishes for decorative and for electrical insulation purposes, and for various platings on steel or iron. The gage can measure with reasonable accuracy the thickness of a non-magnetic coating as thin as 0.0001 in., if the coating has been applied to a steel sheet 0.007 in. or more in thickness. If it is desired to measure the thicknesses of materials such as paper and celluloid, sheets can be fitted to an iron or steel plate for accurate readings. (143)

PORCELAIN ENAMEL. The porcelain enameling art has been advanced in the last year and a half with the development and introduction of new coating and finishing materials. Among the new products placed on the market are two new ground coat frits which when used together, give a long burning range together with freedom from ground coat defects, the range of opaque enamels has been increased, cover coat enamels for colors have been improved to give not only brighter and clearer colors, but also greater freedom from the scumming, hairlining and other defects which are sometimes encountered when enameling. Acid resisting enamels have been improved in working qualities which possess increased opacity. Special acid resisting enamels for architectural use are now available in all color combinations both in glossy and satin finishes. New lead-bearing cast iron enamels of greater workability and freedom from defects have been developed in clear, opaque and black enamels. New enamels for use in the dry process and kitchen ware fields are also available. (144)



Kodak Bantam F.4.5, designed by the Eastman Kodak Company, has a lightweight die-cast aluminum shell, chromium finished by a newly developed, low-cost aluminum plating process that requires no special equipment for successful plating

Thermostatically controlled, a 600 watt element hermetically sealed between two spun brass shells provides heat for this heating device for home cooking, known as the "Heet-Up." Handle and grip are molded of heat-resistant phenolic plastic. Styled by Barnes and Reinecke for the Helmco Sales Company

ENAMEL FRIT that has high reflectance, workability and a wide firing range as a super-opaque frit for one-coat enamel. It is reported to have high tear resistance and high opacity. An addition of 4 per cent tin oxide increases reflectance 2½ per cent. This frit is fired at a comparatively low temperature and is said to reduce warpage to a minimum. (145)

RECOAT WORK ENAMEL compounds are reported that stabilize the color and reflectance of the enamels so that ware can be recoated several times with it without changing the color or reflectance appreciably from the accepted shop standard. Since good covering power is essential in a recoat enamel, regular cover coat whites are used on production lines as a base. Then, to offset the increase in reflection value that such enamel gives to ware recoated with it, a carefully balanced combination of materials has been developed with specific light absorption properties. The materials are carefully balanced so that regardless of the amount of recoat enamel applied to a piece of normally operated ware, the final color will not be any more blue-white or green-white than normally operated ware. (146)

PORCELAIN ENAMEL FINISH. Space heater manufacturers will be interested in a newly developed porcelain enamel finish that consists of a "ground coat" oversprayed with a supplementary liquid. A single labor application and a single firing provides a genuine porcelain enamel finish. The finish being inorganic, it is immune to discoloration, heat cor-

rosion and absorption. It can be applied either to cast iron or to sheet steel. (147)

COLOR PLATING. There are now in operation three companies who do job plating in electrolytic color plating, as well as a number of licensees who have installed their own plants for coloring their own products. The products colored by this group of companies include those that are used in the automobile industry, articles of personal adornment, lighting fixtures, etched metals, escutcheons, decorative panels, gift ware and interior decorations. (148)

PLATING ON ALUMINUM. A practical and simple process for plating aluminum with ordinary plating room equipment has been developed in which the article to be plated is first cleaned in an alkaline cleaner at about 80 deg. F. It is then anodized in a mild acid for 10 minutes. The anodic film is modified in an alkaline bath and the article is then ready for plating in any standard nickel solution with ordinary current densities and under the usual plating shop practices. The process can be used with articles made from pure aluminum or any of the commercial alloys used in sand, permanent mold, and die castings as well as the various alloys used in sheets, plates, bars and other shapes. The solutions used in preparing the aluminum are easily obtained. (*See camera illustrated on opposite page.*) (149)

NICKEL PLATING. Recent developments in nickel plating and the introduction of automatic machinery make it possible to plate continuously strip steel and to fabricate pressed and drawn articles directly from this product. Articles which would be difficult to buff in the fabricated state can be made from steel strip plated in this manner and since buffing is the most important cost item in nickel plating, the overall cost can be materially reduced. (150)

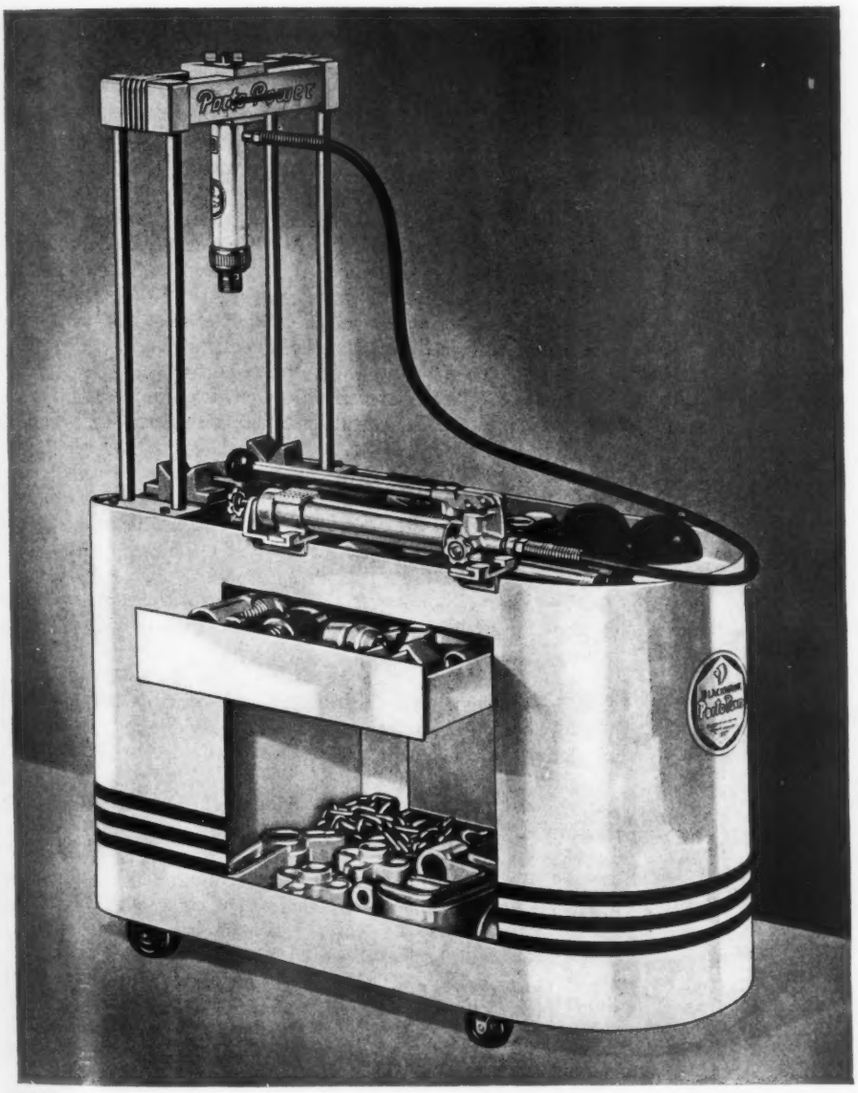
ELECTROPLATING COPPER. The latest process for the electroplating of copper reduces the plating time required to less than one-fourth of that required by existing alkaline plating methods. It is expected that this new development will have an important effect in permitting savings in the cost of plating. (151)

PROTECTIVE COATINGS. For the protection of iron and steel parts of machines, and tools against friction and corrosion a material and process have been developed that maintains high lubricating quality and prevent scuffing, scoring and seizing. The process requires only immersion of the cleaned metal parts in a boiling solution of the compound. In the heated bath the surface of the metal is transformed into a layer of iron and manganese phosphates. Then the parts are rinsed in hot water and dried. When subjected to friction this new outer layer quickly becomes a smooth bearing surface that absorbs and retains lubricants and prevents excessive wear. The process is controlled with such accuracy that tolerance limits are easily held. (152)

ADHESIVE PAPER. A protective paper covering which adheres to the metal by a special gum is now being used with bonded metals where severe drawing and forming operations are encountered. It is stated that the material draws and bends without any harm to its mirror-like finish. After the part is formed the paper coating can be peeled off easily and all traces of gum removed with a cloth. (153)

COLORED STRIP STEEL. A new material has been designed to save finishing costs. The material is strip steel which can be obtained in any color and any width up to 8 in. The material withstands bending, forming and slight drawing operations. Bending will not mar the finish. The material is available with color on one or both sides over white or electrogalvanized finishes. The material is also available in a bright steel finish with longitudinal designs rolled into the strip to improve appearance and save on finishing costs. (154)

COLORED METALS. A pre-finished metal available in a variety of colors and finishes is available for window trim, display stands, signs, panels, buttons, advertising specialties, toys and stamped parts. The finish is rust and tarnish proof. The base metals used are copper-zinc, copper-steel and copper-tin. The material can be easily stamped or formed and is available in sheets up to 36 in. by 96 in. in all gages. (155)



Heavy gage sheet steel, electrically welded, finished in red enamel and trimmed with chrome fittings, forms the base of portable hydraulic repair machine designed by the Blackhawk Manufacturing Company. The ten-ton ram may be anchored in any position across the width of the press. Styling was done by Barnes and Reinecke

PLUGS, CAPS AN

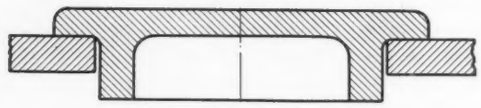


FIG. 1

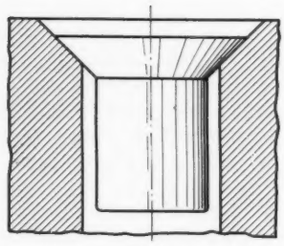


FIG. 2

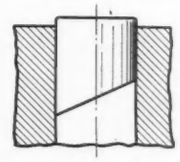


FIG. 3

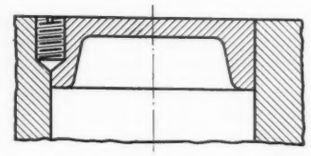


FIG. 4

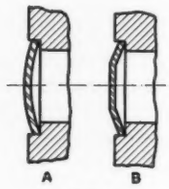
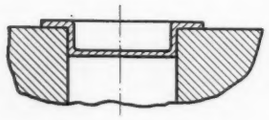


FIG. 5



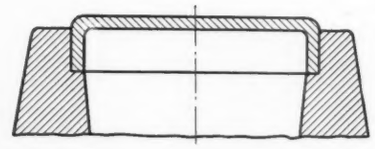


FIG. 6

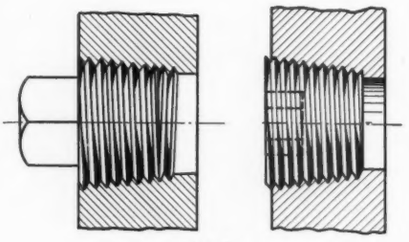


FIG. 8

FIG. 7

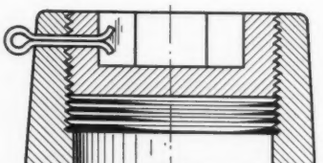


FIG. 10

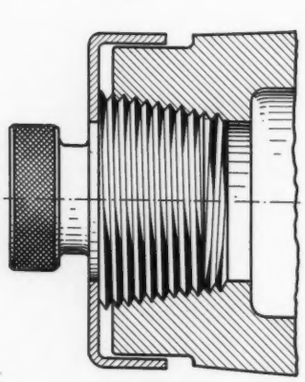
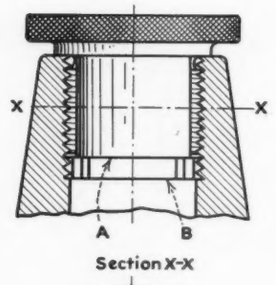


FIG. 9



Section X-X

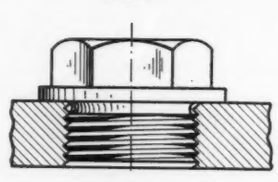


FIG. 11

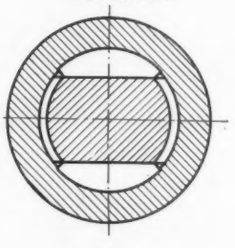


FIG. 12

Many instances occur in the design of machine tools, household appliances, automobiles and other mechanical contrivances, where holes must be covered or filled to keep out foreign materials, retain grease or oil, protect working parts against injury, or to improve appearance. Various methods of capping and plugging such holes are detailed below

HENRY J. MARTIN

FIG. 1—Cover of sufficient weight to stay in place by gravity. If a flat finished surface is desirable, the cover may be recessed.

FIG. 2—To avoid chips falling through hold-down bolt holes in machine tools, taper-headed plugs can be inserted.

FIG. 3—A plain plug with end chamfered or rounded will enter a hole satisfactorily, but in this instance the plug end is as sheared, and the extra chamfering operation is unnecessary.

FIG. 4—When the hole is large, a plug of cast iron is inserted and held in place by a tangential headless screw.

FIG. 5—The "Welch" expansion plug is used universally. At *A* the original shape is shown. Flattening the center portion, as at *B*, expands it.

FIG. 6—A cupped plug made of sheet metal. Slight pressure at the center will expand plug sufficiently to hold. Similar type of hole cover has a seating flange.

FIG. 7—When oilhole cover must be frequently removed, a brass or steel plug with the end slit as shown will hold firmly when inserted into the hole.

FIG. 8—Common pipe plug of malleable iron or brass is used not only for oil drain holes, but in larger sizes can be used for inspection holes. Socket heads are available, as shown.

FIG. 9—For extra precautions against dust, the plug is pipe-threaded and shouldered for a sheet metal dust cap.

FIG. 10—Hole is finished with straight fine-pitch thread. The plug, having fairly loose fit, is held in place by cotter pin.

FIG. 11—A straight fine-threaded plug with hex. head has integral collar. Boss of casting is finished for proper contact with flange.

FIG. 12—Threaded portion is slabbed off as shown in end view. Threads in hole are also relieved so that 90 deg. turn disengages threads. At *A* is end of plug and at *B* end of relieved threads in hole.

FIG. 13—Plug taking end thrust of member *A*. Plug is slotted

PS AND COVERS–I

and fitted with tap bolt to expand plug threads in hole when proper adjustment is attained.

Fig. 14—Provisions for an oil retainer are made in the use of an asbestos-copper sealing ring or spark plug gasket. The hex. head of the plug is turned down for a washer effect to contact the gasket properly. These gaskets are procurable in numerous commercial sizes.

Fig. 15—Where an acorn-type of nut is used, sealing is effectively accomplished by use of a soft lead gasket. The casting, if fairly smooth, need not be machined as the lead will flow sufficiently for a proper joint. The integral washer portion of the nut can be larger than the hex. nut as shown or can be made as in Fig. 14, using a smaller lead gasket.

Fig. 16—Large cast iron or sheet metal covers with cork or composition gaskets for sealing. They can be fastened with a centrally-placed screw as illustrated or with a series of smaller screws near the periphery of the cover. In the method shown, the hand screw has a retaining ring so the screw cannot be separated from the cover.

Fig. 17—Top of sheet metal oil filling tube has a flange which is slotted diametrically opposite, as shown on the left of the center line. Into these slots two projections *A* of cap enter. Cap is then given a turn of approximately 135 deg. to lock. Two opposite projections *B* on cap form finger grips.

Fig. 18—Similar arrangement to that of Fig. 17, except that stiff flat spring *A*, 3/8 in. wide is riveted to cap. The spring ends enter the two slots as shown to right of centerline and cover is turned to locking position. The periphery of cap has straight knurl to facilitate turning.

Fig. 19—Another method of capping oil filling tube. Fiber washer is centered by round projection on formed locking piece *A*, both pieces being riveted to auxiliary cover *B*. Cap *C*, which has an enameled outer surface, is spun over the auxiliary cap.

Fig. 20—Oil level gage with hole-sealing washer is made of half-round wire bent in form of handle at upper end. End *A* is sheared off at an angle and is sprung outwards. Spring pressure against side of hole holds it in place.

Fig. 21—Similar method except that round wire, smaller than oil hole, is flattened and portion *A* in center of flat is extruded as shown to bear against side of hole. Four bearing surfaces, 90 deg. apart, keep gage from rattling. Steel-backed felt washer protects hole entrance.

Fig. 22—Die-cast or sheet steel oil hole cover in vertical or angular position is held closed by gravity. Top end is riveted to casting. May be hung at angle of 30 deg. to horizontal if necessary.

Fig. 23—Similar to Fig. 22 except that coiled spring under pivot screw keeps cover in any position desired. Handle *A* makes shifting possible. This type of oil hole cover has an additional advantage over the method illustrated in Fig. 22 as it can be used in horizontal positions.

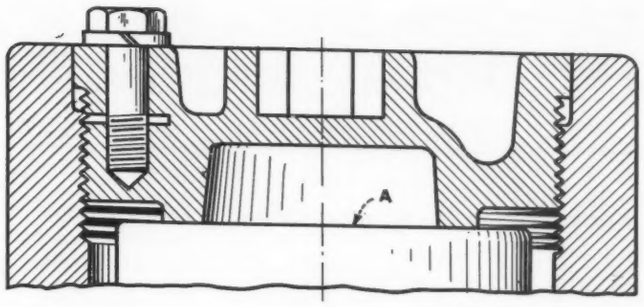


FIG. 13

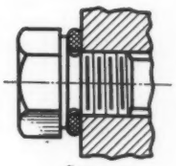


FIG. 14

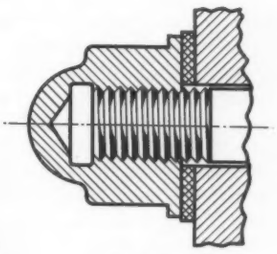


FIG. 15

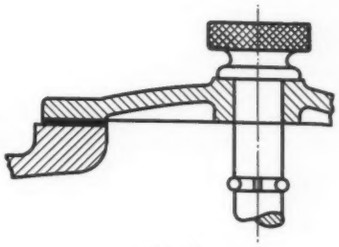


FIG. 16

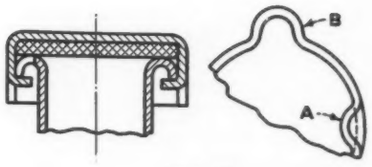


FIG. 17

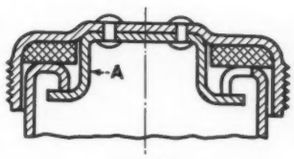


FIG. 18

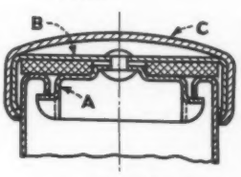


FIG. 19

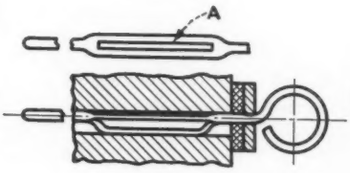


FIG. 21

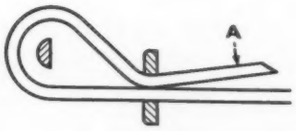


FIG. 20

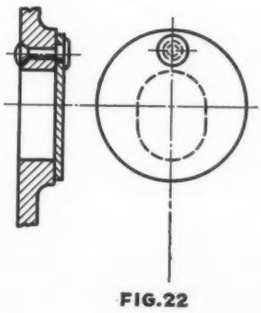


FIG. 22

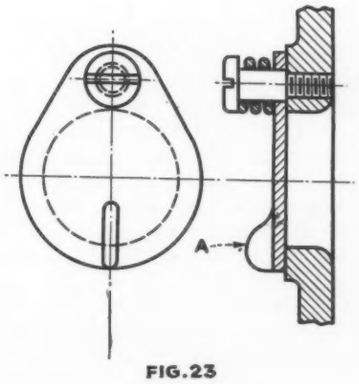


FIG. 23

Books and Bulletins

Formulas for Stress and Strain

RAYMOND J. ROARK. *326 pages, 6x9 in. Clothboard covers. 19 tables. Published by the McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $3.00.*

Many engineers will welcome the publication in book form of Professor Roark's tabular formulas, most of which have appeared in *Product Engineering* as Reference Book Sheets. Intended primarily as a reference manual for designing engineers, the book contains a compact summary of the formulas, facts and principles pertaining to strength of materials required for accurate methods of stress analysis in modern machine and structural design.

The book is divided into three major parts: Part I, definitions and symbols; Part II, facts, principles and methods; Part III, the behavior of structural elements under various conditions of loading, with tables of formulas for calculation of stress and strain. These tables include combined stresses, beams, combined axial and transverse loading, curved beams, circular rings, torsional deformation, stress and deformation in pressure vessels, factors of stress concentration, and numerous others.

A considerable number of examples illustrate the application of the various formulas and methods. No derivations or detailed explanations of the formulas are given; but complete references are listed at the end of each chapter. The tabulated formulas are also indexed to the listed references.

Practical Designs for Drilling and Milling Tools

C. W. HINMAN. *First Edition. 162 pages, 6¼x9¼ in. Clothboard covers. Published by the McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $2.50.*

The author of this book has had many years experience in tool design and has written the book primarily to fill the needs of men who wish to master the art of tool engineering. Following his introductory chapters the author gives a chapter on shop mathematics, followed by one on mathematical short cuts and one on evolution and involution. These chapters on mathematics are written in admirably clear and simple manner, avoid all higher mathematics and cover about all of the mathematics needed by the tool designer.

Typical chapter headings include types of drilling jigs, work clamps and supports for drilling and milling tools, cams and fastenings for jigs and fixtures, equalizing clamps, milling fixtures, fixtures and methods for tapping, air-operated fixtures and types of heavy-duty jigs and fixtures in practice.

It is a well written book that should appeal to any one who aims to master tool design.

Artificial Light and Its Application

258 pages, 8½x11 in. Paper covers. Published by the Commercial Engineering Dept., Westinghouse Lamp Div., Westinghouse Electric & Mfg. Co., Bloomfield, N. J. Price 75 cents.

This is perhaps one of the most comprehensive books available on the subject of artificial lighting. Contents includes descriptions of the various types of light sources available such as types of bulbs, bases, filaments, and the characteristics and efficiencies of the various electric lamp bulbs. Subsequent chapters are devoted to an explanation of the various definitions encountered in lighting, types of photometers and their operation, light and vision, color, light control, interior lighting, industrial lighting, etc.

The book is not only a record of facts invaluable in their application to lighting problems, but is also an excellent textbook on the science of light.

• •

Column Strength of Various Aluminum Alloys

R. L. TEMPLIN, R. G. STURM, E. C. HARTMANN, M. HOLT. *Technical Paper No. 1, 21 pages, 8x10½ in. Published by the Aluminum Company of America, Pittsburgh, Pa.*

Presenting in summarized form the results of some 500 column tests made at the Aluminum Research Laboratories on various aluminum alloys having a wide range of mechanical properties. Structural shapes, tubes, and solid round rods are included, the tests being made with both flat and round ends.

Manufacturers' Publications

ALLOYS FOR ELECTRONIC TUBES—Driver-Harris Co., Harrison, N. J. Loose-Leaf Data Book. Engineering data on alloys for electronic tubes, containing tables and formulas of derived constants to simplify calculations, data on grid alloys, and including curves on sag characteristics.

LUMARITH—Celluloid Corp., 10 East 40th St., New York, N. Y. A set of booklets on the process of molding with Lumarith powders, "Lumarith for Molding," "Lumarish Testing Methods," and "Lumarith Manual on Molding."

RELAYS—Ward Leonard Electric Co., Mount Vernon, N. Y., Bulletin 351, 4 pages, 8x10½ in. Describing three types of thermal time delay relays, including descriptive details, dimensional drawings, and specifications.

STANDARDIZED BEARINGS — The Bunting Brass & Bronze Co., Toledo, Ohio. Catalog 39, 52 pages, 8½x11 in. Their 1939 catalog listing of hundreds of different sizes of completely machined and finished standardized bronze bearings. Also includes the new Bunting precision bronze cored and solid bars of bronze bearing metal, lead base and tin base babbitt and other special products; and data on oil grooving, graphiting and special operations in bearing manufacture.

STEEL BUYERS' GUIDE—Joseph T. Ryerson & Son, Inc., 16th & Rockwell Sts., Chicago, Ill. Stock List, 248 pages, 4¾x8½ in. Giving complete listings and descriptions of the wide range of certified steels and allied products carried in stock by the company. Also included are reference tables, weight charts and standard specification listings.

TEMPERATURE INDICATORS AND RECORDERS —Thwing-Albert Instrument Co., 3339-41 Lancaster Ave., Philadelphia, Pa. Bulletin M-382, 4 pages, 8x10½ in. Covering their line of instruments for measuring and controlling temperature together with their line of instruments for testing paper.

"THE WELDER'S TROUBLE SHOOTER"—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Booklet B.2150-A, 8 pages, 3½x6½ in. Listing the common troubles met by welders such as distortion, welding stresses, cracked welds, undercut, etc., together with the cause and cure for each.

TRANSFORMERS—Eisler Engineering Co., 740-770 South 13th St., Newark, N. J., Catalog 38-T, 24 pages, 8½x11 in. Including about 100 illustrations showing "Transformers in the Making," and a complete line of distribution transformers, spot welding transformers and many types of special and standard transformers used in various industries.

"TWIN ENGINED FOR PROGRESS"—Allegheny Ludlum Steel Corp., Brackenridge, Pa. 12 pages, 8½x11 in. Presenting the story of the merger of Allegheny and Ludlum, briefly outlining the growth of the parent companies, their contributions to the steel industry, developments leading up to the merger, and future plans.

Stresses and Deflections in Trunnions and Drum Heads

F. L. REQUA
Oliver United Filters, Incorporated

ECONOMICAL utilization of material in the design of large trunnion-supported drums, such as are used in continuous filters, ball-mills, and the like, requires knowledge of the stresses and deflections imposed on the members by the loading. In the case of filters having a closed drum submerged in the liquor, the loading is equal to the difference between the weight and the buoyancy of the drum. In many designs buoyancy predominates and in some the load due to net buoyancy is considerably greater than the weight of the parts. A type of drum construction commonly employed is illustrated in Fig. 1. Typical dimensions of such a drum in the filter industry would be 8 ft. in diameter by 8 to 16 ft. in length with shell and drum-heads of quarter-inch steel plate. It is obvious from these proportions that, without ribs, the thin plate drum head has little rigidity, but the ribs alone, without the head, possess great rigidity against bending (see Fig. 2).

In the development of the following formulas the drum head is assumed to be non-existent. Each pair of diametrically opposite ribs is treated as a beam restrained at the ends and subject to a bending moment at the center. This bending moment has its maximum value when the beam under consideration is vertical, and decreases to zero (as a cosine function of the angle to the vertical) when the beam is horizontal.

If there were but four ribs (i. e. two beams at right angles) in the drum-head it is obvious that the maximum resisting moment would occur in a beam when it occupied a vertical position; the value would be equal to that of the trunnion moment bW in Fig. 2. More generally, it can be shown that the maximum value of the resisting moment in any pair of ribs, considered as a beam, is

$$m = \frac{4M}{N} \tag{1}$$

where m is the maximum resisting moment of a pair of opposing ribs in inch-pounds,

M is the trunnion moment, in. lb., and N is the number of single radial ribs.

Note that in order that each rib may be part of a diagonal beam, N must be an even number. In practice, however, an odd number of ribs is often specified. In such cases, the deflections and stresses will lie intermediate to those of the next higher and lower number of ribs. It is permissible, therefore, to assign to N its actual value, even or odd, in the above and following formulas without incurring serious error.

The value of the bending moment at the center of a pair of diagonally opposite ribs varies as the drum rotates, as was noted above. If θ is the angle between one of the ribs and the vertical, then

$$m_\theta = m \cos \theta = \frac{4M}{N} \cos \theta \tag{2}$$

where m_θ is the value of the resisting moment at the angle θ (Fig. 3).

In Figs. 4 to 9 the symbols used have the following meanings:

b = drum head moment arm, the distance from the center line of the rib to the point of application of trunnion load, (usually the center line of the bearing), in.

b' = trunnion moment arm, the distance from the trunnion flange to the point of application of trunnion load, in.

d = diameter of trunnion flange, in.

D = inside diameter of drum shell, in.

f_s = maximum fiber stress in rib, at shell end, lb. per sq. in.

f_t = maximum fiber stress in rib, trunnion end, lb. per sq. in.

F_o = stress in each trunnion stud, due to tightening up on nut, lb.

h = depth of rib, in.

k, k_1 k_2 constants

I = moment of inertia of rib, in.^{4}

M = total moment Wb, in. lb.

M_t = bending moment in a single rib at point adjacent trunnion, in. lb.

M_s = bending moment in a single rib at point adjacent shell, in. lb.

n = number of trunnion studs, equally spaced on same bolt circle

N = number of ribs in the head (a rib is considered as extending from the trunnion to the shell)

R = horizontal reaction exerted between one rib and the shell, lb.

t = thickness of rib, in.

S = section modulus of rib, in.^{3}

T = torque reaction between rib and shell, in. lb.

W = total trunnion load, lb.

y = distance along rib, measured from shell toward trunnion, in.

Δ = deflection of trunnion at point of application of trunnion load.

Fig. 4 covers the common case where the ribs are of constant depth and are rigidly joined to the shell and the trunnion. The trunnion is assumed to be of infinite rigidity as

compared to the ribs and the effect of the drum head in stiffening the ribs is neglected. The formulas applying to this case are:

$$M_s = -\frac{Wb}{N} + \frac{D^2 + Dd - 2d^2}{D^2 + Dd + d^2} \qquad M_t = +\frac{Wb}{N} \times \frac{2D^2 - Dd - d^2}{D^2 + Dd + d^2}$$

$$\Delta = \frac{Wb^2}{4NEI} \times \frac{(D-d)^3}{D^2 + Dd + d^2}$$

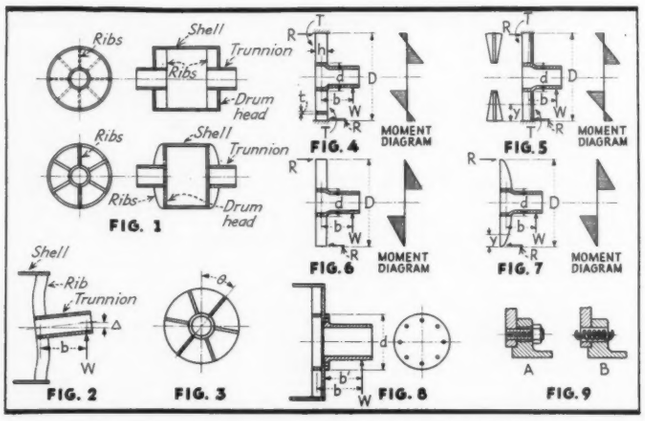
$$I = \frac{th^3}{12} \qquad R = \frac{6Wb}{N} \times \frac{D+d}{D^2 + Dd + d^2}$$

$$T = \frac{Wb}{N} \times \frac{D^2 + Dd - 2d^2}{D^2 + Dd + d^2} \qquad f_s = \frac{M_s}{I} \qquad f_t = \frac{M_t}{I}$$

Fig. 5 covers the same constructions as shown in Fig. 4 except that provision has been made mathematically whereby some account may be taken of the effect of the drum head in stiffening the ribs. Thus the formulas are based on a rib construction stiffer at the shell than at the trunnion (due to the flaring triangle of drum head associated with each rib), but the variation of the moment of inertia from trunnion to shell has been assumed to vary with the distance y thus:

$$I_y = \frac{k_1}{k_2 + y} \tag{3}$$

in order to keep the formulas from becoming unwieldy. In using this set of formulas the designer will estimate the value



of the moment of inertia of the rib at the shell and at the trunnion, I_s and I_t, and then evaluate the constants k_1 and k_2 by the relations.

$$k_1 = \frac{I_s I_t}{I_s - I_t} \times \frac{D-d}{2} \qquad k_2 = \frac{I_t}{I_s - I_t} \times \frac{D-d}{2} \tag{4}$$

deduced from equation (3). The formulas for the case shown in Fig. 5 are:

$$M_s = -\frac{2Wb}{N} \times \frac{(D-d)(D+3d) + 4k_2(D+2d)}{Z} \times (D-d)$$

$$M_t = \frac{2Wb}{N} \times \frac{(D^2 - d^2) + 4k_2(2D+d)}{Z} \times (D-d)$$

$$\Delta = \frac{Wb^2}{12NEk_1} \times \frac{(D-d)^2 + 12k_2(D-d) + 24k^2_2}{Z} \times (D-d)^3$$

$$R = \frac{8Wb}{N} \times \frac{(D-d)(D+2d) + 6k_2(D+d)}{Z}$$

$$T = \frac{2Wb}{N} \times \frac{(D-d)(D+3d) + 4k_2(D+2d)}{Z} \times (D-d)$$

$$Z = (D-d)(D^2 + 2Dd + 3d^2) + 8k_2(D^2 + Dd + d^2)$$

$$f_s = \frac{M_s}{I_s} = \frac{M_s k_2}{k_1}$$

$$f_t = \frac{M_t}{I_t} = \frac{2k_2 + (D-d)}{2k_1} \times M_t$$

Fig. 6 covers the same case as Fig. 4 except that the ribs are considered to be flexibly joined to the shell. This condition is, of course, not realized in practice but the formulas developed are useful in forming an estimate of the effect of a very thin shell, which may be considered to exert relatively little restraining torque against rib bending. The formulas are:

$$M_s = 0 \qquad M_t = \frac{2Wb}{N} \times \frac{(D-d)}{D}$$

$$\Delta = \frac{Wb^2}{3NEI} \times \frac{(D-d)^3}{D^2} \qquad R = \frac{4Wb}{ND}$$

$$f_s = 0 \qquad f_t = \frac{M_t}{I}$$

Fig. 7 illustrates a case similar to Fig. 6 except that the ribs taper off as shown, in such manner that the maximum fiber stress is the same for all values of y. This condition is satisfied when

$$S = k_1 y \quad \text{or,} \quad I = k\, y^{3/2} \tag{5}$$

The formulas are,

$$M_s = 0$$

$$M_t = \frac{2Wb}{N} \times \frac{(D-d)}{D} \qquad \Delta = \frac{4\sqrt{2}\,Wb^2}{3NEK} \times \frac{(D-d)^{3/2}}{D^2}$$

$$R = \frac{4Wb}{ND} \qquad f_s = 0 \qquad f_t = \frac{M_t}{I_t} = \frac{M_t}{ky^{3/2}} = \frac{M_t}{k\left(\frac{D-d}{2}\right)^{3/2}}$$

Fig. 8 shows the conventional method of bolting the trunnion to the drum head. Stud nuts must be tightened in assembly until the stress in each stud is equal to or greater than the maximum stress which will be imposed on it by the drum load. Under this condition each stud behaves as a stressed spring (Fig. 9) forcing the trunnion against the drum head collar. So long as the external moment does not exceed the combined moment of all the springs, the trunnion will remain seated against the collar. Since the only way in which the stress in a spring can be increased is to increase the distance between the ends of the spring, it is obvious that so long as the external moment caused by drum load does not exceed the initial clamping moment of all the studs, the stresses therein will not exceed the initial clamping stresses.

Because of this spring function of the studs, either the threads should be run the full length of the stud or the body undercut to a diameter equal to the root diameter of the threads.

The size and number of studs required is determined from the equality of moments equation:

$$Wb' = F_0 n \frac{d}{2} \qquad \text{from which:} \qquad F_0 n = \frac{2Wb'}{d} \tag{6}$$

Note that equation 6 does not contain the radius of the bolt circle because the total resisting moment of the bolts is independent of the radius of the circle on which they are located.